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The World thenceforth becomes a Temple and life itself one continued act of adoration.

Boston: Published by Gould, Kendall & Lincoln.

CLASS BOOK

OF

NATURAL THEOLOGY;

OR THE

TESTIMONY OF NATURE

TO THE

BEING, PERFECTIONS, AND GOVERNMENT OF GOD.

BY THE

REV. HENRY FERGUS.

The living God, which made heaven, and earth, and the sea, and all things that are therein.......................................Acts xiv. 15.

REVISED AND ENLARGED,

AND ADAPTED TO

PAXTON'S ILLUSTRATIONS;

WITH

NOTES, SELECTED AND ORIGINAL, BIOGRAPHICAL NOTICES, AND A VOCABULARY OF SCIENTIFIC TERMS.

BY THE

REV. CHARLES HENRY ALDEN, A. M.,

PRINCIPAL OF THE PHILADELPHIA HIGH SCHOOL FOR YOUNG LADIES.

Third Edition, Revised.

BOSTON:

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STEREOTYPED AT THE
BOSTON TYPE AND STEREOTYPE FOUNDRY.

PREFACE.

A Class Book of Natural Theology, adapted, both in matter and price, to our numerous schools of a higher order, has long been wanted, and the want regretted by many judicious parents and teachers. In respect to the increasing number of our seminaries for young ladies, especially, the want has, hitherto, had no remdy in the form of a text-book. In that justly popular and invaluable work, Paley's Theology Illustrated, there are, it is found, some things not well adapted to the ordinary circumstances of female instruction, and even of young gentlemen in many of our more common select schools; but, for our higher seminaries of learning, for our colleges and theological institutions, this work is considered indispensable.

A distinct object with the Editor of the following work, has been to render it strictly appropriate both to the public and private education of Young Ladies; there being no topic in it which may not be discussed with entire propriety under any circumstances.

The Notes will be found important and interesting; and the adaptation of the whole to Paxton's admirable Illustrations, is too obviously useful and attractive to require comment.

The Biographical Notices, suggested by the Editor's knowledge of the general deficiency among the young in this kind of literature, are necessary to intelligent students, to whom large works on Biography, Encyclopedias, &c. are not accessible. The place of residence and the works, as well as the circumstances of the honored benefactors of the world, and the period when they flourished, ought early to be known. This kind of knowledge is, to the young, naturally interesting; and the result is, or ought to be, a grateful remembrance of such men, and a disposition to profit by their labors.

The VOCABULARY OF SCIENTIFIC TERMS will be found useful to such as have not had opportunity to cultivate a familiar acquaintance with the elements of Natural History, Philosophy, and Science.

Though a truism, it is not useless to repeat it,—an intelligent and judicious course of instruction is a matter, in our country, of paramount importance. As soon as our youth have comprehended the principles of Natural History, Natural Philosophy, Astronomy, and Chemistry,—and this they may now do at an early age,—they can with profit enter on the study of Natural Theology. Under the direction of intelligent and faithful instructers, a knowledge of this science can scarcely fail to confirm moral principle, lead to habits of discrimination and study, enlarge the views of the tendency of human actions, encourage confidence in good men and good designs, and thus add to the resources, the strength and the adorning of a country whose only way to "exaltation is virtue."

The influence of the study of this science on individual piety and excellence, commends it to the attention of the best friends of man. In the language of one whose purity of character and chastened sensibility have done more than any other in our language to invest Virtue in her native attractiveness,

> In the vast, and the minute, we see
> The unambiguous footsteps of the GOD
> Who gives its lustre to an INSECT'S wings,
> And wheels his throne upon the ROLLING WORLDS.—*Task.*

To those engaged in the responsible duties of instructers, the Editor has no suggestions to offer as to the use of this, as a textbook. They will not fail to interest their classes by adding at each recitation something from the stores of their own experience and observation, and endeavor to make every accession of knowledge on the part of their pupils an increase of practical wisdom.—Est animorum ingeniorumque naturale quoddam quasi pabulum consideratio contemplatioque naturæ: erigimur; elatiores fieri videmur.—*Cicero.*

PHILADELPHIA, *June*, 1835.

TO

MRS. EMMA WILLARD,

THE DEVOTED AND SUCCESSFUL PROMOTER OF FEMALE EDUCATION,

THIS WORK IS INSCRIBED,

WITH SENTIMENTS OF HIGH CONSIDERATION

BY

THE EDITOR.

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BOOK III.

THE PERFECTIONS OF DEITY.

INTRODUCTION.

The proofs of the Being, Perfections, and Government of God may be indefinitely increased; for, as our knowledge of creation extends, the evidences of design multiply upon us. It is the aim of the following Treatise to show, within narrow limits, that contrivance, wisdom, and goodness appear not in one province only, but in every department of the Universe which falls under our observation. Ray, Derham,* and Paley have distinguished themselves in this branch of learning; and of their excellent works the Author has occasionally availed himself.

The subject is of universal interest, and has a paramount claim to earnest attention. Without reverence for Deity, man is a degraded and forlorn prodigal; but religion felicitates and exalts our nature; and it is the first step in religion to believe that God is, and "that he is the Rewarder of them who diligently seek him." Creation declares the existence of the Creator, invites us to contemplate his perfections in the works of his hand, reminds us of our relation to Him in "whom we live, and move, and have our being," and claims our grateful adoration for his unwearied kindness towards us. To accustom ourselves to recognize the hand of God in the

* Ray was an English naturalist, who, from a very humble origin, rose to distinction. He was a fellow at Cambridge, but resigned on the restoration of Charles II., from political considerations. He devoted the remainder of his life to science and literature, and became the author of several works on Natural History and Natural Theology. The work referred to in the text is entitled "The Wisdom of God manifested in the Works of Creation." He died 1705, æt. 77. Many of his writings were afterwards collected and published by *Derham*, of Oxford, who devoted his life to philosophy, humanity, and religion. He was author of no fewer than forty works, chiefly on philosophical subjects. His "Astro-Theology," and his "Physico-Theology," published in 1714, are the volumes here referred to. He died 1735, æt. 78.

appearances of nature and the events of providence, to observe the adaptation of parts to each other, and the combination of means for the attainment of ends, is an exercise worthy of the high faculties which our Maker has bestowed upon us, and cannot fail to promote both our intellectual and moral improvement.

To whatever quarter we turn our eye, we find ample materials for this study. Animate and inanimate nature are alike instructive; and their relation to each other indicates that unity of counsel which presided in the formation of the world. The atmosphere, for example, though invisible, connects distant and dissimilar parts of the system, and combines them for the accomplishment of beneficial purposes. Without it no animal could live, no plant grow, no light shine, and no sound be heard; all would be sterility, desolation, and silence. But the earth is fitted up as a pleasant habitation for many sentient creatures. Man is its noblest inhabitant; and, in order to understand the plan of the Almighty with regard to him, it is necessary to attend to his character and condition. He is a rational, immortal, and accountable being, in a course of education for a higher stage of existence. He is subject to trials; and those trials have been eagerly seized, and plausibly urged, as inconsistent with the attributes of a benevolent Creator. The structure of the earth, the qualities of some of the inferior animals, and the vices and miseries of mankind, have been favorite arguments among infidels. To meet and answer the skeptical conclusions which have been drawn from these facts, is the design of a considerable portion of the following work; but we trust its limits will not be considered as exceeding its importance.

BOOK I.

THE ORIGIN OF THE WORLD.

CHAPTER I.

THE GENERAL BELIEF OF MANKIND.

CRANTZ,* in his History of Greenland, tells us that a native of that country once addressed him in the following manner :—" It is true we were ignorant heathens, and knew little of God till you came. But you must not imagine that no Greenlander thinks about those things. A kajak (a Greenland boat), with all its tackle and implements, cannot exist but by the labor of man. But the formation of the meanest bird requires more skill than that of the best kajak ; and no man can make a bird. There is still more skill required to make a man : by whom then was he made ? He proceeded from his parents, and they from their parents. But some must have been the first parents ; and whence did they proceed ? Common report says they grew out of the earth. If so, why do not men grow out of the earth still ? And whence came the earth itself, the sun, the moon, and the stars ? Certainly there must be some Being who made all these things— a Being more wise than the wisest man." Such was the reasoning of the untutored inhabitant of the frozen coast of Greenland; and in some such way have mankind always reasoned ; for no truth has been more universally received than the existence of God. " Who," says Ælian,† " does not

* " The History of Greenland, containing a Description of the Country and its Inhabitants, and particularly a Relation of the Mission carried on by the Unitas Fratrum," London, 1787—a well-executed and highly-interesting work.

† For an account of this writer, and of those he here refers to, see *Anthon's Lempriere's Classical Dictionary*, to which the student should refer as often as a classic author is named, unless already familiar.

admire the wisdom of the barbarians, none of whom ever fell into the atheistical absurdities of Eumenes, Diagoras, Epicurus, and other philosophers? No Indian, Celt, or Egyptian, ever questioned whether there were Gods, or whether they concerned themselves with the affairs of men."

Some errors and some vices characterize society in particular stages of its progress, or when placed in peculiar circumstances; but atheism is never the error of society, in any stage or in any circumstances whatsoever. It is the hypothesis of a few thinly-scattered individuals in civilized nations, at times when, from caprice, vanity, and ostentation, the most obvious truths are denied, and the most whimsical and pernicious paradoxes are zealously published and defended. Belief in the existence of God has prevailed in every age, and in every quarter of the world, and in every stage of society. In this point the savage and the sage have agreed. The rude hunter of the wilderness, and the polished inhabitant of the magnificent city, between whom there is a vast difference of habits, of knowledge, and of opinions, unite in the belief of the existence of Deity, and with equal earnestness supplicate his favor. On this subject, the great error has been, not the denial of one God, but the belief of many: polytheism, however, has been a popular and poetical rather than a philosophical error. Men have entertained false notions of the nature of God, but still they have believed in his existence; and the erroneous conceptions which have accompanied this belief, instead of attaching any discredit to the interesting truth, tend to confirm it. They show that the existence of Deity is so plainly engraven on the face of nature, and so consentaneous to the dictates of reason, and to the unperverted feelings of the human mind, that it meets with a ready reception. even when accompanied by absurdities.

Is it alleged that some tribes of human beings have been found, among whom no traces of belief in the existence of Deity were discoverable? The allegation is questionable. Of these tribes we know too little to speak with certainty of their creed; and even supposing the affirmation founded on fact, it must not be forgotten, that those tribes are in a state of extreme degradation; and that they are not to be considered as denying the existence of God, but as being so brutal as to have no opinion or belief on the subject. Belief in the existence of Deity has all the authority which it can derive from opinion: it has the general suffrage of the human race. This is no slight presumption of the truth of the thing believed; for where mankind, in all the different circumstances in which they have been placed, have generally agreed on any great point relating to their common interest, their agreement may fairly be interpreted as the dictate of their nature, and consequently may be considered as having a rational claim to general reception.

For the general belief in the existence of God, there must be an adequate cause. Where shall we find such a cause but in the appearances of the universe indicating a powerful, wise, and good Being, the Creator of all things? It is in vain to attribute this belief to tradition. Tradition cannot account for the fact; for the question immediately occurs, What was the origin of the tradition? Besides, no mere tradition could have been so widely and permanently diffused: it could not have been preserved among all tribes of men, and amidst all the vicissitudes of the human race. The flimsy allegation which ascribes the origin of this belief to the artifices of interested politicians, is unworthy of notice, and may be dismissed with contempt. If general opinion and belief, then, could place any truth beyond the reach of controversy, the question concerning the being of God would, long ere now, have been finally determined; for on no other points have mankind so generally agreed as in believing the existence of God, and the immortality of the soul. But, although belief in the existence of God has been general, yet it has not been universal; for the fool, says an ancient sage, has said in his heart, There is no God.

The general belief of mankind is not, of itself, decisive evidence of the truth of the thing believed. But, even as evidence, it is not hastily to be dismissed from our minds, unless we can point out, in a clear and satisfactory manner, the causes of general error. Men have been led to the conclusion that there is a God by the appearances of the universe; and if those appearances, when calmly and rationally contemplated, justify the conclusion, then the opinion which it establishes is entitled to a cordial reception by the candid and serious inquirer after truth. It has, indeed, been attempted, in different ways, to evade the conclusion now mentioned. It has been alleged by some, that the world is eternal; and others have been of opinion that the universe is a casual production. These speculations claim some notice, although they need not detain us long.

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CHAPTER II.

THE ETERNITY OF THE WORLD.

The belief of the first men of whose opinions we have any record, the progressive population of the world, the recent origin of arts and sciences, ancient tradition and early history, all militate against the eternity of the world. We are not now speaking of inert matter only, but of the whole system of things as we see it. For if it be admitted that any part of the system is not eternal, then the whole hypothesis falls to the ground. Either all is eternal, or we have no reason to conclude that any part is so. But how can the human race be eternal? I exist; but I do not necessarily exist, for once I was not. I did not bring myself into existence. My parents were not their own creators: and although I go back as far as the wing of imagination can bear me, still I am as unable satisfactorily to account for the existence of those whom I then find alive, as I am to account for my own existence, or for the existence of those who have lived at any intermediate period. By going backward, I remove the difficulty from one point to another; but still, at any given point, that difficulty is just the same as when it first met me. According, however, to the constitution of my nature, I cannot rest satisfied till I come either to a self-created or to a necessarily-existing being. But a self-created being involves a contradiction. It involves existence and non-existence at the same time. I must, therefore, arrive at a necessarily-existing, and, consequently, eternal Being, as the *first cause* of my own existence.

Thus I think, that, according to the constitution of my nature, I must either believe in an eternal and intelligent first cause, or in something at least equally incomprehensible, and also altogether absurd. To talk of an infinite succession of beings such as man, is merely an unphilosophical attempt to push out of sight the difficulty of accounting for our first formation; but that difficulty it in no degree removes. For, according to this hypothesis, how high soever we ascend, we find no animated being but what has derived its existence from a being of the same kind with itself. Still we meet with plain marks of design; but the designing cause we have not found. Contrivance is obvious; but the contriving mind, which must have existed before the contrivance, we have not discovered. It may be added, that the speculations of those who have attempted to trace the vestiges of the human race to a very remote antiquity, have not been successful. There is no reason to believe that men have existed on the earth above six or seven thousand years.

Our globe has undergone some great revolutions. This the structure of its parts, and the organic remains found in it, clearly prove. But these revolutions were antecedent to the race of Adam. The organic remains indicate no traces of human beings. Neither reason nor revelation require us to believe, that the matter of this world was first called into existence at the time of the creation mentioned in the Jewish Scriptures. It may have existed before in different forms, and may have undergone many changes. But having been deranged and reduced to a chaotic mass by some mighty catastrophe, it was then fitted up for the reception of new inhabitants and the exhibition of new scenes, and was subjected to laws adapted to the new order of things.

Geological speculations can never be successfully employed in ascertaining the antiquity of the human race; for how shall we determine the state of matter when our globe was first subjected to the operation of those laws under which it now exists? To apply the result of observations on the present order of nature to a state of things anterior to, and perhaps altogether different from, the present system, can lead to no correct conclusions. In an investigation of this kind, the very first point to be ascertained is, the state of matter when the present system of laws began to operate; a point which no human industry or ingenuity can ascertain; and without which, any speculations on this subject, with a view to determine the antiquity of the world, are mere illusions. Nay, from the phenomena of the existing system, rash and hasty conclusions may be drawn, which, although at first sight plausible, will not bear the test of examination. The argument of Recupero, founded on the lavas of Ætna, might have been considered decisive, had not the ruins of Herculaneum demonstrated its fallacy.

The astronomical arguments which have been adduced on this subject, are as deceitful and unsatisfactory as those of a geological kind. Astronomy is incomparably the more advanced of the two sciences; but the history of astronomy is imperfect, and, on some points, very uncertain. Much has been said of the high antiquity of the Indian astronomical tables; but the eloquence of Bailly* and the science of

* A famous astronomer of Paris, author of the "History of Ancient and Modern Astronomy," and of "Indian and Oriental Astronomy," and other valuable works. He was guillotined during the reign of Terror in France, 1793.

Playfair have not succeeded in proving them to be founded on observation. There is good reason to believe that they were formed by computation. This is the opinion of La Place, and it is strongly supported by the arguments of Bentley.* The probability is that Indian science, instead of being of high antiquity, was derived from the Arabians, through the Greeks and Persians. According to Montucla, the distinguished historian of science, the most ancient Chinese observations are 2155 years before the Christian era; being, according to Usher's† chronology, about 160 years before the birth of the patriarch Abraham. If the Fohi‡ of the Chinese be the Noah of the Hebrew Scriptures, he may have transported into that country the faint lights of antediluvian science.§

An argument in favor of the high antiquity of the human race has been founded on the zodiacs in the temples of Latopolis and Tentyra, two ancient cities in the Upper Egypt. This argument rests on a great astronomical fact—the precession of the equinoxes. The equinoctial and solstitial points do not invariably occupy the same places in the ecliptic, but have a retrograde motion of about $50\frac{1}{3}''$ in the year; by which they will accomplish a revolution in about 25,750 years. Now, in the zodiac of Latopolis, the modern Esneh, Leo, we are told, is represented as the last of the ascending signs; and it has been stated that a sphinx there represents the sun at the summer solstice, just in the point where the last degree of Leo meets the first degree of Virgo. But at present, the colure of the summer solstice is in the first degree of Gemini; and therefore it has been inferred, that as the space between the first degree of Gemini and the last degree of Leo, is to the whole of the ecliptic, so must the period elapsed since the construction of the zodiac of Latopolis be to 25,750 years. This inference would no doubt be consequentially drawn, if it were proved that the above was a true explanation of the zodiac of Latopolis, and that *that* zodiac was a correct picture of the heavens at the time of its formation. But on these points, doubts and suspicions crowd in upon us. Plutarch and Macrobius would have been surprised and

* An eminent critic and divine, who, from an humble origin, raised himself to high distinction. The work of his here referred to, is "Critical Observations on John Malala's Chronology." This superior scholar died, 1742, æt. 80.

† Archbishop of Armagh, a distinguished scholar and divine, and author of a most elaborate and invaluable work here referred to—"Annals of the Old and New Testaments." His productions were various and numerous.

‡ Fohi was, according to the Chinese, the founder of their monarchy, about 20 years after the deluge. He is said to have reigned 115 years. His memory is still revered in China.

§ Wallace's Dissertation on Hindoo Astronomy.

amused to hear the sphinx spoken of as an emblem of the sun. The Egyptians, it is true, worshipped that luminary under different names and symbols; but the sphinx was not one of them. To imagine, then, that this symbol represents the sun, is a gratuitous and unauthorized assumption.

Besides, there is no good reason to believe that the zodiac of Latopolis was a correct picture of the heavens at the time of its formation. Although we allow the highest praise to the genius and industry of ancient astronomers, yet it cannot be denied that their instruments were rude and clumsy, and many of their observations inaccurate. They erred more than half a degree in the latitude of Syené, a place at no great distance from Latopolis; and does this encourage the presumption that they were qualified to give a correct delineation of the zodiac? The Egyptians were, moreover, very vain, and boasted of a high antiquity. After the days of Hipparchus, might they not give false representations of the heavens, with a view to countenance and encourage this vanity? It may be remarked, that the decorations of the Egyptian temples are not of the same antiquity with the temples themselves.

Farther, in the zodiac of Tentyra, the modern Dendera, Leo is not represented as the last of the ascending, but as the first of the descending signs. Does not this show that one, if not both of those zodiacs, is posterior to the time of Hipparchus? For, if one of those zodiacs represents Leo as the last of the ascending, and the other as the first of the descending signs, was not this (supposing those zodiacs to be correct) a demonstration that the solstitial, and consequently the equinoctial, points are movable? But this, as is well known, was the grand discovery of Hipparchus,—a discovery in no degree owing to the zodiacs of Latopolis and Tentyra, but made by comparing his own observations with those of Aristyllus and Timochares, about 150 years before. Hipparchus diligently inquired into all the observations of Chaldean and Egyptian astronomers; but, although it is probable that the former of those nations cultivated astronomy before the latter, yet he could find no observations that had been made at Babylon, previous to the reign of Nabonassar, 747 years before Christ. Berosus, a Chaldean, who lived about 300 years before the Christian era, knew of no monuments of Chaldean astronomy more ancient than 480 years before his own time; and neither Hipparchus nor Ptolemy ever heard of observations for 1903 years transmitted by Callisthenes to Aristotle, about the year 331 before Christ. Simplicius, a peripatetic philosopher, and commentator on Aristotle, who lived in the sixth century of the Christian era, makes mention of such observations; but his authority and that of Porphyry, from whom he borrowed the story, are too modern to be entitled to any regard. In short, these Egyptian zodiacs were unknown to Hipparchus; and if they had existed in his time, would they have escaped the notice of that careful observer and indefatigable inquirer? Would he not have appealed to them, as well as to the observations of Aristyllus and Timochares, in proof of the precession of the equinoxes? But it is needless to dwell longer on the subject, for there is no evidence that the Egyptians had zodiacs, with our signs and names, before the establishment of the Greeks in that country.*

It has been said that all things sprung from *necessity*. Necessity, however, is not an agent, but the state or condition of an agent; and if they who use the word, in the sense under consideration, attach any distinct conceptions to their language, they must by it understand an agent acting necessarily. But an agent acting necessarily is in reality no agent, but merely an instrument in the hand of another. Such, however, is the constitution of our nature, that we cannot rest satisfied till we find a being operating, not by necessity, but by will and choice. We must find an efficient cause that had power to give, or not to give, existence to every creature. Necessity must result from something antecedent to itself.

Some persons talk of *appetency*. What do they mean by the word? Is it chemical affinity? If it be so, we understand the signification of the language, but cannot conceive with what propriety it is introduced on the present occasion. Has chemical affinity ever formed an organized being? If any person hazard the affirmative, let him produce an example: this he cannot do. But *appetency*, it may be said, is an endeavor perpetually and imperceptibly working its effects through a long succession of generations. We know that the perennial mountain stream operates insensibly, and in the course of ages hollows out a channel in the rock; but we know of no such operation producing either a plant or an animal.

To talk, as some have talked, of "Nature forming the first rudiments of organization, or spontaneous generations,

* Dr. Richardson, in his Travels, thinks it requires a good deal of imagination to make the drawings in these temples zodiacs; and some late interpreters of the hieroglyphics make them the work of Roman emperors.

which gradually, in a long series of ages, and under the modifying influence of different circumstances, appear in all the organized forms which exist on the earth," is, to say the least of it, something that requires explanation, or that cannot be proved. What are we to understand by *Nature?* The word may be used figuratively for the Author of Nature; or it may mean that order and constitution of things which the Supreme Intelligence has established and maintains. In this last sense, it is of the same import with the *Laws of Nature.* Now, to talk of the laws of nature, to the exclusion of an Intelligent Agent, is absurd. The very term *law* implies such an agent. Law is not an agent. It is not endowed with active power, and therefore cannot be a cause, in the proper sense of the word. Law is the expression of mind, and the rule according to which intelligence acts. Without the agent the law is nothing. Without his agency it never could have existed, for it merely expresses the manner of his procedure.

Where is the proof that Nature has formed all her productions after long periods of time? Show us an example of the first rudiments of organization, or a spontaneous generation. Show us any one of those rudiments in the first stage of its progress, or undergoing any of those metamorphoses through which it passes in advancing to a more perfect form. At any assumed point, tell us what was its last form, and what will be its next. Men and other animals are still such as they have always been. But a hypothesis, countenanced by no known fact in nature, has no legitimate claim to the character of philosophy, and may be fairly dismissed as a dream.

CHAPTER III.

CHANCE.

Some persons have been of opinion that *Chance* was the author of all things. What is Chance? In common language, by this word we express our ignorance of a cause, or our want of intention. When we say a thing happened by chance, we do not mean to describe chance as the cause of the fact or event, but merely to say that we are ignorant of the cause, or that the event happened without intention on our part. The atheist, however, uses the word to the exclusion of an intelligent and designing cause from the formation of the universe. But how did chance produce either matter or motion? We may indeed be told that we are equally ignorant how an intelligent cause operated in the production of those effects. It may be so. But by the introduction of Deity, we assign an intelligent and sufficient cause for all the phenomena, although we may not comprehend the manner in which this cause operated in their production.

But although matter and motion be given, the difficulties of the chance philosopher are little diminished. How do chance, matter, and motion, produce an organized substance? How do they form a sentient being? How do they constitute and maintain a system of animated and rational existence? We confidently affirm that chance, matter, and motion, have never formed, and never will form, an organic structure. Let all the men of the world employ the best efforts of their reason and ingenuity in arranging and combining matter in thousands and millions of different ways, still they cannot produce a single plant or a single animal in any other than the common way. By a proper adjustment of the temperature, they may supply the incubation of the bird; but without the bird they cannot form the egg. Has chance, then, produced that rich and beautiful variety of vegetable, sentient, and rational nature, which adorns and felicitates our earth? and is Man, with all his reason and science, unable to succeed in a single instance? That unthinking and undesigning chance should produce intelligent and designing beings, is a notion utterly unfit for gaining admission into the human mind. The understanding of mankind revolts from it. Their observation and experience pronounce it untrue.

If the fortuitous concourse of atoms has formed all things—if the different orders of sentient beings have sprung from accidental combinations of matter—how happens it that alchemists and chemists, in all their mixtures for discovering the philosopher's stone, or even for making phosphorus, have not hit upon any new combination which produced a living creature—a fly or a frog, a monkey or a man? Franklin has taught us to rob the clouds of their lightning. Galvani*

* The physiologist of Bologna, and the famous discoverer of that branch of electricity which bears his name—Galvanism. While preparing broth from frogs for his sick wife, he perceived the muscles of these animals violently convulsed, by the touch of a dissecting knife. He devoted much attention to the subject, and ascertained a great number of facts now well known. He died 1798, æt. 61. The subject was further investigated and reduced to a more perfect system by Volta, whose name is given to some modifications of galvanic apparatus.

and Volta have discovered combinations of matter by which, even after the vital spark is extinguished, the animal frame can be thrown into violent contortions. But no philosopher has discovered a new process for forming any one living creature. It is not unreasonable, however, to think that, if the system of the chance philosophers had any foundation in truth, new processes for making living creatures would long ere now have been discovered; and that he would have been as well acquainted with receipts for forming animals of new kinds, and also with different ways of making those that formerly existed, as we are with prescriptions for procuring oxygen gas, or red fire.

If chance produced all things at first, why do we not see chance operating still? If chance reared the world, why do we never see it building a palace or a cottage? If chance made man, why does it never draw a portrait? If all things be the offspring of chance, how happens it that we do not see new forms rising into life—animals unheard of before appearing in the world; and all the fictions of the poets realized? How happens it that the casual concurrence of atoms does not derange the system which it had formed, and alter it in a thousand different ways; that we never see a tree changing into a man, nor a man dwindling into a mushroom; nor a human head united to a horse's neck? Has chance stumbled blindly on till it reared the beautiful and magnificent fabric of the Universe; till, in every instance, throughout the whole extent of nature, it hit upon the only possible combinations from which such noble results could proceed, and then forever ceased from its blind and stumbling operations? The supposition is too extravagant to gain admission, for a moment, into a sober and rational mind. Indeed, the whole hypothesis of the chance philosophers is rather to be considered as an instance of the strange vagaries of the human imagination, than as a system capable, in any degree, of bearing the test of reason, or satisfying the mind of the serious and candid inquirer after truth.*

* The ancient chance and atomic philosophers were not agreed among themselves. Some of them, as Epicurus, supposed the atoms, which, by their fortuitous concourse, formed all things, were inanimated: others, as Democritus, believed them animated; teaching a doctrine perhaps essentially the same with the living organic particles of more recent times. Whence did these atoms derive their animation?

CHAPTER IV.

DESIGN.

The opinion that the system of the world has been eternal cannot bear examination; and the hypothesis which ascribes the origin of the universe to a casual concurrence of atoms is utterly unsatisfactory. To arrange and organize matter, as we see it arranged and organized in the fabric of the world, is the work of mind; for in the fabric of the world, we every where see plain indications of design and contrivance. But where there are design and contrivance there must be intelligence. The intelligent being may act either mediately or immediately; but still he must exist and act. It may be assumed as the dictate of our nature that every effect must have an adequate cause. Such is the constitution of our minds, that this is equally the conviction of the savage and the sage. Wherever we see the fit combination of means in order to the attainment of an end, we thence, invariably and without hesitation, infer the existence of a designing cause.*

The possibility of discovering design by its effects has been denied; but there are some things which, by the very constitution of our nature, we are compelled to believe. The conviction is universal and irresistible, and can neither be weakened by metaphysical fallacies, nor strengthened by demonstration. The man who attempts to make me doubt my own existence, or that of matter around me, may puzzle my understanding by the subtilty of his reasoning, or dazzle my imagination by the splendor of his eloquence; but he makes no impression on my belief. The same is the case with him who tells me that I can have no conception of active power, or who labors to persuade me that I cannot discover design in its effects. In spite of his distinctions and his acuteness, my belief remains unchanged. He no more alters the convictions of my mind than the color of my skin. For

* Without entering into any abstruse speculations about causation, we may, with Dr. Reid, remark, that, in common language, *cause* is a very vague word, and is applied to any antecedent that is connected with the effect. In Natural Philosophy, when we speak of a *cause*, we mean a law of nature from which the phenomenon results. This is a *physical* cause; it means the law or rule according to which the *efficient* cause acts. But in Mental Philosophy, when we speak of a cause, we mean an *efficient* cause; that is, a being with understanding, will, and power, equal to the production of the effect. Nothing but an efficient cause can give existence to that which had no existence before; and, in a series, the efficient cause must begin it, and establish the law by which it is carried on.

by attending to my own voluntary actions, I have a conception of active power. I am conscious of my own volitions, and experience teaches me that these volitions are followed by corresponding effects. Now, although I am unable to understand or explain the manner in which mind acts upon matter, yet I have all the evidence of which the case admits, or which my nature requires, that my volitions and exertions are the efficient cause of the effects produced. Wherever I observe mutual adaptation, reciprocal dependence, the relation of parts to one another, and to a common end, there I believe there has been design. The belief is invariable, and it is certain. I am led to it by all my notions resulting from consciousness, perception, testimony, and inference. Experience proves it invariably true.

Aristippus was shipwrecked on an island, where he and his companions were apprehensive of being destroyed by barbarians, or torn to pieces by wild beasts. He perceived some geometrical figures roughly sketched on the shore. "Let us take courage, my friends," exclaimed he, "for I see the vestiges of civilized men!" The judgment which he formed was instantaneous and certain. He never suspected that those figures had been scratched by the talon of the eagle, the paw of the lion, or even by the finger of a savage. If, however, upon landing on an unknown shore, instead of a few figures roughly sketched on the sand, we were to find a geometrical treatise, such, for instance, as the first six books of Euclid, with all the propositions, diagrams, and demonstrations, would any one hesitate, for a single moment, to pronounce that this was the work of some civilized and intelligent being? No man capable of exercising reason would pronounce it the work of chance. Would a voyager, landing on an uninhabited island, and finding a magnificent and splendid city, adorned with palaces, and temples, and towers, imagine, because he saw no inhabitants, that the city had risen up there without the operation of an intelligent agent? No: a native of Oriental climes might pronounce it the work of the genii; but no person would imagine that it had come there without a designing cause, a contriving mind.

It is by the inference of design from its effects, that, in many instances, we form our opinions and regulate our conduct. How do we distinguish a man of sagacity from a fool? a person of integrity from a villain? Why do we punish the incendiary and the murderer? It is because our opinions are formed and our conduct regulated by the inference of design from its effects. And before we cease to think in this manner, we must divest ourselves of our nature; we must cease to be men. This principle, which is forced upon us by the very constitution of our nature, and which is confirmed by daily experience, we must carry along with us when we survey the universe. We cannot divest ourselves of it. If, therefore, in our examination of Nature, we perceive combinations and relations which, according to all our notions, indicate design, then we are irresistibly led to infer the existence of a designing cause. This is no wanton hypothesis, no gratuitous assumption. It flows from a principle deeply rooted in our nature, and which influences many of our opinions, and much of our conduct.

It may, perhaps, be said that our knowledge of the design of the artist in any piece of mechanism, or of the architect in planning and building a palace or a city, arises from our having seen other things of the same kind, and having been informed of the *design;* but that the universe is something of its own kind; that it is *one* only; that there is no fair analogy between it and any work of man; and that, therefore, we cannot trace *design* in it. It is true, indeed, that the universe is but one. It consists, however, of many parts; and if, either in the whole, or in any of the parts, we perceive those kinds of combinations and relations which, according to the constitution of our nature, and all our observation and experience, we consider as indicative of design, then we are as irresistibly led to infer the existence of a designing cause in the one case as in the other. And in proportion as the universe, or any part of it, is superior to any effect of human contrivance and power, so the designing cause must, in the same proportion at least, be superior to man in wisdom and might. A watch is but one; yet it consists of many different parts, and plainly indicates design and contrivance. And though there were only one watch in the world, no man in the possession of his reason would pronounce it a casual production.

The distance between the construction of any piece of mechanism, and that of the vast system of the universe, is, indeed, immeasurably great. This, however, does not destroy the analogy; but it greatly weakens the impression of that analogy on our minds. In comparing a mite with an elephant, we, in some measure, lose sight of the comparison by the immense disparity between the things compared. This is much more the case in comparing the world with a piece of mechanism. In order to see and feel the full force of the comparison, there must be something like equality between the things compared; or, at least, we must be able to compute the inequality. For it is only in proportion as we are able distinctly to see, and accurately to compute the difference between the things compared, that we feel the force of the comparison. But the disparity between the universe and the effects of human ingenuity and power is incalculable, and therefore the argument from analogy does not make a due impression on our mind.

We do not pretend fully to understand the designs of God in his works; but to argue that we can know no part of those designs, because we cannot comprehend them in all their variety and extent, is attempting to draw a general conclusion from partial premises. Because we do not fully understand the economy of the comets, can it be logically inferred that we know nothing of the solar system, or of the design of the sun? Will any man assert that we are ignorant of the design of the organs of sense, because we cannot explain how the nerves, connected with different organs, produce different sensations? Such conclusions, drawn from such premises, are not entitled to much consideration. To state them plainly is a sufficient refutation. The man who denies that it is any part of the design of the sun to enlighten, warm, and fertilize the earth; or of the eye to see, and of the ear to hear; or who seriously maintains that, from the effects, we cannot fairly infer such a design,—is unquestionably under the influence of very powerful prejudices. In these instances the relations are obvious; and every unperverted mind must be fully satisfied that it is the design of the sun to communicate light and heat to the earth—of the eye to see, and of the ear to hear. These we may confidently assume as designs of the Deity; and may reason concerning the fitness of the means to accomplish the ends, and, from that fitness, may form our estimate of the attributes of the Supreme Intelligence.

In inquiring into the designs of the Creator in his works, there is no presumption. Our inquiries ought to be conducted with profound reverence for the Being who formed and who upholds the universe; and, when so conducted, instead of being indications of impiety or audacity, they are expressions of admiration and homage. The essence of Deity is not the object of our senses; but he exhibits himself to us in his works, and in these he invites us to contemplate the proofs of his existence and the glory of his perfections. To trace the hand of the Almighty in the fabric of the universe, is a suitable exercise of the noble faculties with which he has endowed us: it is a tribute of homage to Him who made us; and must be the means of much improvement and happiness to ourselves. "The works of the Lord are great, sought out of all them that have pleasure therein."*

* The *a priori* argument I have not introduced, because, to my mind, it has never appeared very satisfactory. Dr. Reid (Intell. Powers, p. 314, 4to ed.) says, "Sir Isaac Newton thought that the Deity, by existing every where, and at all times, constitutes time and space, immensity and eternity. This probably suggested to his great friend Dr. Clarke, what he calls the argument *a priori* for the existence of an immense and eternal Being. Space and time, he thought, are only abstract or partial conceptions of an immensity and eternity which forces itself upon our belief. And as immensity and eternity are not substances, they must be the attributes of a Being who is necessarily immense and eternal. These are the speculations of men of superior genius. But whether they be as solid as they are sublime, or whether they be the wanderings of imagination in a region beyond the limits of human understanding, I am unable to determine."

Professor Dugald Stewart, in his Dissertation on the Progress of Metaphysical, Ethical, and Political Philosophy, in the Encyclopædia Britannica, Part II. p. 65, says, "How far the peculiar cast of Newton's genius qualified him for prosecuting successfully the study of mind, he has not afforded us sufficient *data* for judging; but such was the admiration with which his transcendent powers as a mathematician and natural philosopher were universally regarded, that the slightest of his hints on other subjects have been eagerly seized upon as indisputable axioms, though sometimes with little other evidence in their favor but the supposed sanction of his authority. The part of his works, however, which chiefly led me to connect his name with that of Clarke, is a passage in the *Scholium* annexed to his *Principia*, which may be considered as the germ of the celebrated argument *a priori* for the existence of God, which is commonly, though I apprehend not justly, regarded as the most important of all Clarke's contributions to metaphysical philosophy. I shall quote the passage in Newton's own words, to the oracular conciseness of which no English version can do justice.

"'Æternus est et infinitus, omnipotens et omnisciens; id est, durat ab æterno in æternum, et adest ab infinito in infinitum. Non est æternitas et infinitas, sed æternus et infinitus; non est duratio et spatium, sed durat et adest. Durat semper et adest ubique, et existendo semper et ubique durationem et spatium constituit.' Proceeding on these principles, Dr. Clarke argued, that as immensity and eternity (which force themselves irresistibly on our belief as necessary existencies, or, in other words, as existencies of which the annihilation is impossible) are not *substances*, but *attributes*, the immense and eternal Being, whose attributes they are, must exist of necessity also. The existence of God, therefore, according to Clarke, is a truth that follows with demonstrative evidence from those conceptions of space and time which are inseparable from the human mind."

After quoting the passage from Dr. Reid, cited at the beginning of this note, Mr. Stewart proceeds and says, "After this candid acknowledgment from Dr. Reid, I need not be ashamed to confess my own doubts and difficulties on the same question."

Dr. Thomas Brown, in his 92d lecture, says, "If the world had been without any of its present adaptation of parts to parts, only a mass of matter, irregular in form, and quiescent,—and if we could conceive ourselves, with all our faculties as vigorous as now, contemplating such an irregular and quiescent mass, without any thought of the order displayed in our own mental frame,—I am far from contending that, in such circumstances, with nothing before us that could be considered as indicative of a particular design, we should have been led to the conception of a Creator. On the contrary, I conceive the abstract arguments which have been adduced to show that it is *impossible* for *matter* to have existed from eternity,—by reasonings on what has been termed *necessary existence*, and the incompatibility of this necessary existence with the qualities of matter,—to be relics of the mere *verbal logic* of the schools, as little capable of producing conviction as any of the wildest and most absurd of the technical scholastic reasonings on the properties, or supposed properties, of *entity* and *nonentity*. Eternal existence, the existence of that which never had a beginning, must always be beyond our distinct comprehension, *whatever* the eternal object may be, material or mental,—and as much beyond our comprehension in the one case as in the other, though it is not impossible for us to doubt that *some* being, material or mental, must have been eternal, if *any thing exists*."

Sir James Mackintosh, in his Dissertation on the Progress of Ethical Philosophy, in the seventh edition of the Encyclopædia Britannica, speaking of Dr. Clarke, says, "Roused by the prevalence of the doctrines of Spinoza and Hobbes, he endeavored to demonstrate the being and attributes of God, from a few axioms and definitions, in the manner of geometry; an attempt in which, with all his powers of argument, it must be owned that he is compelled sometimes tacitly to assume what the laws of reasoning required him to prove; and that, on the whole, his failure may be regarded as a proof that such a mode of argument is beyond the faculties of man."

In a note, Sir James adds, "This admirable person had so much candor as in effect to own his failure, and to recur to those other arguments in support of this great truth, which have in all ages satisfied the most elevated minds. In Proposition VIII. (Being and Attributes of God, p. 47), which affirms that the first cause *must* be 'intelligent' (where, as he truly states, 'lies the main question between us and the atheists'), he owns, that the proposition cannot be demonstrated strictly and properly *a priori*."

Having mentioned these high authorities, I shall add nothing of my own respecting the argument *a priori*.

BOOK II.

EVIDENCES OF DESIGN IN NATURE.

CHAPTER I.

GENERAL OBSERVATIONS.

We shall now proceed to consider some of the evidences of design in the fabric of nature; and, instead of selecting a few insulated examples from particular departments of the world, shall take a rapid but wide survey of the universe, and endeavor to show that evidences of design occur every where throughout the vast system. Such evidences appear, not merely in a few thinly-scattered phenomena of a dubious aspect, pressed into the service, and constrained to give a reluctant and suspicious testimony, but they abound in every province of nature, and, upon many occasions, force themselves upon the notice even of the careless observer. Such a general survey is not necessary to prove the being of God; but it will serve to familiarize this great truth to our imagination, and accustom us to associate the existence and perfections of Deity with the contemplations of his works. Moreover, we may often have occasion to remark the indications of wisdom and goodness which appear in every department of nature; and the frequent recurrence of these indications cannot fail to make a deep impression on the mind, and to fortify it against objections to those attributes of the Creator. Before entering, however, upon this extensive survey, it is proper to premise,

1. That, although we may not understand every phenomenon, or be able to point out design in every appearance of nature, yet this can form no objection against what we are able to explain. Our ability to prove the existence and illustrate the perfections of Deity from the fabric of the universe,

will be commensurate with our knowledge of creation. We may be able to show design in many phenomena; but beings of greater knowledge may show wisdom and goodness in many more, perhaps even in those very instances which to us appear most perplexing and unaccountable. Hence we may see the folly of condemning what we do not understand. Perceiving so many indications of wise and benevolent contrivance every where around us, we ought rather to distrust our own knowledge than to deny the existence of wisdom and goodness in any particular instance. The celebrated Alphonsus X., king of Leon and Castile, was well acquainted with the astronomical doctrines of Ptolemy, but had no conception of the true principles of the solar system. Proud, however, of his attainments, and misled by his imaginary science, he is said to have exclaimed, that if he had been of God's council he would have instructed him better in the construction of the universe. What the royal astronomer ridiculed was not the work of Deity, but the fantom created by his own ignorance. His example should operate as a caution to us.

2. Although I err in my account of one phenomenon, and although my argument, in so far as it depends on that erroneous account, must fall to the ground, yet this in no degree invalidates arguments founded on facts and appearances correctly stated. It is not here as in the demonstration of a geometrical theorem, where, if one link be broken, the demonstration fails. In the present case, the reasoning upon every fact, or combination of facts, is separate and independent; and, therefore, although, in any one instance, the statement of fact may be incorrect, and the argument, in so far as it depends on that incorrect statement, unsound, yet other facts and arguments founded on them stand in full force. Every fact, or every combination of facts, may be considered independently, in the great mass of evidence; and in proportion as we bring forward appearances indicative of design, we accumulate arguments in proof of the existence of a designing cause. If we can show a harmonious combination of all the phenomena, in order to the construction of one whole, then the conclusion which results from the contemplation of particular parts will appear with the most attractive lustre and commanding majesty.

CHAPTER II.

THE HUMAN EYE.

In glancing at the evidence of design in nature, I shall first select a particular instance, and explain it at considerable length, in order that the force of the evidence may be more fully felt. The instance which I select for this purpose is the *Human Eye* [Pl. I. fig. 2, 3, 4]; and in reviewing this organ, I shall give a description of it, which, though not minute enough for the anatomist, may suffice for an exhibition of its construction and excellence as an optical instrument.

The *Eye*, which communicates so much beauty and vivacity to the human countenance, is a small but admirable instrument of vision formed in the expansion of the optic nerve. Its position, construction, and the provision made for its adjustment and preservation, plainly indicate a designing cause. It is placed in the upper part of the face, occupying a commanding station; and, like a sentinel posted on a hill, perceiving, at a single glance, every thing around. It is lodged in a strong-hold, or bony cavity, called its *orbit;* and is surrounded by several parts, which serve either to protect it from injury, to assist and facilitate its motions, or to supply it with moisture. The optic nerves proceed separately from the brain: they afterwards unite; then separate again, and each of them enters the orbit, on the nasal side, and forms the integuments of the eye, so that the *coats* or *tunics* of the eye are expansions of the optic nerve, or at least membranes intimately adhering to it. The optic nerve has two coats, one above the other, enclosing its medullary substance. The exterior coat is named the *dura mater;* the interior the *pia mater*. The outer coat of the eye, called the *sclerotica*, is a continuation and expansion of the dura mater, and is white and opaque, excepting the anterior part, called the *cornea*, which, unlike the part behind, is transparent, and is fixed in the sclerotica, like the glass of a watch in its case.

The *Choroides*, which lines the sclerotica, may be considered as a production of the pia mater. Its anterior part, behind the cornea, but not close to it, is of a very different structure from its posterior part; and, on account of the variety of its colors, has been named the *Iris*. [Pl. I. fig. 5, 6.] The Iris, or anterior part of the choroides, is an assemblage of muscular fibres; some of them tending, like the radii of a circle, towards its centre, and others forming a number of concentric circles round the same centre. In the middle of the iris is a perforation known by the name of the *pupil,* which is diminished by the contraction of the circular fibres of the iris, when a very luminous object is presented to the eye, and dilated by the contraction of the radial fibres, for the admission of a greater number of rays in a faint light. Even they who do not admit the fibrous structure and muscularity of the iris, cannot deny its contractibility, which they ascribe to its sympathy with the *retina.*

At the anterior border of the choroides, there is a ring of sensible thickness, named the *ciliary ligament,* from which proceed numerous productions called *ciliary processes.* The posterior surface of the iris, the ciliary processes, and part of the choroides, are spread over with a black *mucus,* which absorbs the lateral rays, and contributes to distinct vision. The medullary portion of the optic nerve, in dilating, forms a white, and very thin membrane, or congeries of nervous terminations, applied upon the choroides, and named the retina; upon which, according to the general opinion, the object is painted. In these coats or tunics are set three transparent *humors* or *lenses,* of different refractive powers; and the whole forms the organ of vision in the human body.

The foremost of the humors is the *aqueous.* It is placed immediately behind the cornea, and occupies the whole space between it and the crystalline humor, both before and behind the iris. The aqueous humor has the transparency of the purest water, but it is not altogether so liquid. Its specific gravity is rather greater than that of water. It has been remarked that, notwithstanding the great fluidity of the aqueous humor, and its exposure to the cold, it does not freeze. Behind the aqueous humor is placed a double convex lens, having its axis corresponding with the centre of the pupil. It is somewhat more convex towards the circumference of the eye than in front. It is called the *crystalline* humor, and appears to be composed of a great number of very thin laminæ, and of extremely minute fibres, very transparent, and closely united together. It is tolerably solid, and both its specific gravity and refractive power are greater than those of either of the other two humors of the eye. It is attached to the ciliary ligament, by means of the fibres of which it can probably be altered in a small degree in position, and perhaps in figure also. The crystalline is placed behind the aqueous, and in front of the *vitreous* humor, in which last it is set like a jewel in a ring. The vitreous humor, situate at the back part of the socket, occupies about three fourths of the globe of the eye. It is of the consistence of a jelly, colorless, and of great transparency. Its specific gravity is little more than that of the aqueous humor; therefore, as, generally speaking, the refractive powers of different mediums are as their densities, the refractive powers of these two humors are not very different. Each of the humors is contained within its own membrane, which is very delicate, and equally transparent with the humor itself. At the back of the whole is the retina.

The eye, thus formed, is provided with muscles which move it in all directions, and accommodate its focal distance to different objects, in a degree of perfection incomparably superior to the mechanism of the most ingeniously adjusted telescope. By the action of six muscles, it has not only the horizontal and vertical motions, but it can be turned to any oblique angle with the rapidity of lightning. The eyeball is much less than the cavity in which it is lodged; but the interval is filled up with cellular substance, furnishing a soft and warm bed to the eye, and facilitating its motions. Besides, by means of the lachrymal gland [Pl. III. fig. 1.] situate between the ball of the eye and the upper vault of the orbit, on the temporal side, the eye is supplied with a perpetual fountain for moistening and keeping it clean; the superfluous moisture passes through a perforation into the nostrils, and is drained off. The eyelids, in connection with the bony cavity in which the ball is lodged, form a soft and strong covering to the eye, and can be instantaneously put on or withdrawn. The eyelashes serve as a protection against insects and minute bodies floating in the air: they also give warning of approaching danger, and help to guard against it; and they moderate the rays of light in their passage to the eye.

Observe, then, what a variety of circumstances, and what an exact combination and nice adjustment of these circumstances, there must be, in order to distinct vision; and after attentively considering the whole, nothing, I think, but blind stupidity or obstinate perversity can deny design and skilful contrivance in the structure of the eye. How happens it that the cornea is transparent, and not opaque like the sclerotica, of which it is the continuation? If it were opaque, there would be no vision; and I see no way of accounting for its transparency, but by acknowledging a wise designing cause. How shall we account for the transparent part being placed in front, and not towards the bottom of the socket? Light does not give transparency to the cornea, nor does the cornea give existence to light; they exist independently of each other; yet, between the two, there is an unquestionable relation, as much so as between the window and the room, the fire-place and the chimney, the lock and the key.

How happens it that the iris is of a different structure from the rest of the choroides, of which it is apparently the continuation?—that the iris has the perforation called the pupil, and that it is not a continuous envelope like the cornea?—that the centre of the pupil corresponds with the axis of the crystalline lens?—and that the iris has a power of contraction and dilatation, either lessening or enlarging the pupil according to circumstances? A change in any of those conditions would be fatal or highly injurious to vision. The light does not create the pupil, yet the pupil is formed for the admission of light. Light does not confer on the iris the power of contraction or dilatation; yet the pupil has the power of adjusting itself to the quantity of light. If it be alleged that the light irritates the retina, and by that means occasions the contraction, still we may inquire, Who so organized the pupil that it should be affected in such a manner by the action of light? who contrived the mechanism by which the changes in the size of the pupil are affected? How shall we account for the ciliary ligament and its processes, and the four *straight muscles*, but by resorting to a wise designing cause, which has in this way provided for the adjustment of the crystalline lens, and for rendering the cornea more or less prominent? [Pl. I. fig. 7.] Who provided the retina, like a fine white canvass, to receive the picture? How shall we account for lenses of different refractive powers to correct the chromatic aberration? Light did not create these several lenses, for they were created ere light shone upon them; nor did these lenses establish the law by which rays of light are refracted from the straight line in passing obliquely through mediums of different densities, and by which some of the rays of the solar beam are more refrangible than others; yet the lenses of the eye are accurately adapted to the optical fact or law. How happens it that the lenses are so exactly adjusted that the rays form a distinct picture on the retina? If the configuration or refractive powers of the lenses had been such as to bring the rays to a focus sooner, or if the retina had been placed more forward, or at the smallest distance farther back in the socket; in any of these cases, vision would have been indistinct. But the place of the retina is exactly adjusted to the focal distance of the lenses.

By fixirg a lens in a hole of the window-shutter of a darkened room, we see an inverted picture of external objects, formed on a white sheet of paper, behind the lens. But, in order to have the picture distinct, we must move the paper backwards and forwards till we find the exact focal distance. The retina, which corresponds to the sheet of paper, is placed exactly at the due distance.

The eye is convex, and not a plane. If it had been a plane, the field of vision must have been extremely limited. But the most advantageous of all forms is adopted; and I know of no rational way of accounting for this, but by having recourse to a designing cause.

But this is not all. In different species of animals, there is a striking and beautiful adaptation of parts of the eye to the peculiarities of each, in respect to modes of living and procuring their sustenance. Birds, for example, in general, procure their food by means of their beak; hence, from the nearness with which their food is brought to the eye, they need the power of seeing distinctly very near objects. Again, from their great elevation as well as velocity of flight, the power of seeing at great distances, and with distinctness, is also necessary. There are accordingly two peculiarities in the eyes of birds, by which distinct vision in these opposite circumstances is effected. The one is a bony, yet, generally, a flexible hoop [Pl. II. fig. 1, 2.], surrounding the broadest part of the eye, which, confining the action of the muscles to that part, increases the effect of their lateral pressure upon the orb, by which pressure its axis is elongated, and thus very near objects are plainly seen. The other peculiarity is, an additional muscle, called the *marsupium* [Pl. II. fig. 3, 4, 6.], for the purpose of drawing back the crystalline lens, as occasion requires, to fit the eye for the perception of distant objects. By these means, the eyes of birds are adjusted to near and remote objects far more readily than those of other animals.

The eyes of fishes, also, exhibit peculiarities of structure adapted to their state and element. In the eyes of these animals, the crystalline lens is perfectly spherical; thus adapted only to near objects [Pl. I. fig. 1.], their indolent habits requiring this peculiar adjustment. The muscular conformation of the eye is calculated only for flattening it. The iris of fishes does not contract, it being unnecessary from the diminished quantity of light in the element in which they live.

In the Eel [Pl. II. fig. 5.], which inhabits the bottom of ponds, there is placed, a little distance above the eye, a horny, transparent covering, which effectually protects this delicate organ from injury from the sand and gravel in which it is often found.

Thus, in comparing the eyes of different animals, we see but one general design, and yet that plan benevolently varying with the exigences of state and habits. How striking, in all this, is the evidence of design!

In order, however, to have a fuller view of the subject, we shall compare the eye, in some particulars, with a telescope, and give a more copious illustration of some things already mentioned.

I. Let us consider the eye as an achromatic instrument. Light moves in straight lines; but in passing obliquely out of one medium into another of different density, it is refracted towards the perpendicular in passing into a denser medium, and from it in passing into a medium more rare. Besides, the white light issuing from the sun is not a homogeneous fluid, but consists of several differently-colored rays; and these rays are not equally refrangible, the red being the least refrangible, and the violet the most so. Unless, however, these refractions be corrected, there cannot be distinct and colorless vision. Such is the fact in nature. How, then, is the matter managed in the eye? The refractions are corrected by lenses of different refractive powers, so that all the rays meet in a focus on the retina, and there delineate a distinct and achromatic image of the object from which the rays proceed. How is the difficulty managed in the telescope? This was long a desideratum in natural science, and exercised the genius and industry of the most distinguished philosophers.

The telescope, by the prismatic action of the lenses of which it was composed, gave the object a colored appearance about the edges, and consequently presented an indistinct image. This was a great defect; and it was of much importance to remedy it. The celebrated Mr. James Gregory* perceived that the eye had the same difficulty to encounter. How, he asked, is it surmounted there? He perceived that this was accomplished by a combination of lenses of different refractive powers. Hence that ingenious philosopher was led to throw out a hint concerning the construction of what has since been called the achromatic telescope. The subject employed the great powers of Newton, and the vigorous

* A Scotch mathematician, born and educated in Aberdeen. He was the inventor of the reflecting or catoptric telescope, and the burning concave mirror. He had the honor of disputing, but on amicable terms, with Sir Isaac Newton, on the comparative excellence of the dioptric and catoptric telescope. He died at the age of 36, in 1675.

mind of Euler,* and the execution of the plan has conferred a lasting celebrity on the name of Dollond.† Here, then, we find Gregory, Newton, Euler, Dollond, names of high distinction (and many more might be mentioned), turning their minds to the formation of the achromatic telescope, acknowledging the structure of the eye to be their guide, and yet employing much ingenuity, and performing many experiments, ere the last of them happily succeeded in accomplishing the object in view. Now, the cases under consideration are precisely parallel: the difficulty to be surmounted is the same. Shall we, then, admit design and contrivance in the one case, and deny them in the other? Shall we admit that Gregory, Newton, Euler, and Dollond, were designing and contriving beings, in their schemes and efforts to construct an achromatic telescope; and yet contend that the eye, which was their model, was formed without design and contrivance? Shall we admit design and contrivance in the imitation, and yet deny them in the pattern? This were absurd in the extreme. In the structure of the eye, design and contrivance are obvious, and that organ could not have been formed but by a designing and contriving Being.

II. In using a telescope,—for instance, a three feet refractor,—if we wish to try the powers of the instrument in reading a book, we may have distinct vision at the distance of twenty or twenty-five yards. But, if we turn the telescope, in the same state in which we have been reading the book, upon an object a mile or two distant, we see nothing. In order to have distinct vision, we must, either by managing the tube with our hand, or by the action of a screw, adjust the instrument to the new distance. In what way soever we perform the operation, it requires time and observation to find the focus.

But the eye adjusts itself in a moment, whether the object which we look at be six inches from it, or six thousand times that distance. Now, is there design and contrivance in forming the adjusting screws of the telescope to fit it to the focal distance? No man in his senses denies it. How, then, can any man in his senses deny design and contrivance in the mechanism of the eye, by which the same end is accomplished; and not only accomplished, but accomplished in a far more easy and expeditious manner than in the telescope? For no degree of practice or dexterity in the use

* A French mathematician, born at Basil, and died at Berlin, 1783, æt. 76. He was a man of the most astonishing powers of mind, and at the same time beloved for his many social virtues, and revered for his piety.

† A London optician. To him belongs the honor of having invented the achromatic telescope.

of the instrument will enable us to adjust its focus to different distances with the same ease and quickness as we do in the eye. If design and contrivance be admitted in the one case, they cannot be denied in the other, but by obstinate and irrational perversity.

III. The form of the eye indicates a wise designing cause. It is of a spherical figure; and by this figure several important ends are answered far better than they could have been by any other. It affords the most convenient lodgment for the humors of the eye, and gives the largest field of vision. If the front of the eye had been a flat surface, there could have been no distinct vision, because all the parts of it could not have been at the due focal distance from the lenses: some parts must have been too near, or some too far off. Besides, it is obvious that the spherical figure of the eye is best adapted for motion in all directions. We may further remark, that the optic nerve enters the eye, not at the bottom of the socket, but on the nasal side of it. This contributes to distinct vision, and may fairly be considered as an evidence of design.

IV. The eye occupies a most commanding position, and surveys with ease every thing around. It could have been stationed in no other part of the body with equal advantage. If it had been placed in the *occiput*, or back part of the head, the form and articulation of the arms and legs would not have harmonized with it; but, at present, they are fitted for acting in the direction in which the eye sees. The eyes and the limbs are admirably adapted to each other. They exhibit a striking instance of relation and prospective contrivance. Indeed, relation and prospective contrivance meet us in almost every department of nature, whether we attend to the structure of animals or to the combinations and adjustments of the different parts of the universe. Thus the eye occupies its due place in the body, as part of one harmonious whole, and all the members are fitted for coöperating with it. It is stationed near the brain, and communicates with that great source of sensation and motion by means of the optic nerve.

V. We have an evidence, not of design only, but of goodness also, in the number of the eyes. They are two. In this way we can take in a larger angle than if we had one eye only; and although one be injured, we are not entirely deprived of the use of this cheering organ. And we may observe the consummate skill of Him who formed the eye, in this circumstance, that, although an object be seen with both eyes, yet it appears single, perhaps because painted on the corresponding part of each retina, or perhaps because the nerves unite; but in what manner soever we account for it, the fact is certain; and the argument resulting from it is not affected by any doubts respecting the manner in which it is accomplished. Although the picture of the object is inverted on the retina, yet we see objects erect; and this, I apprehend, happens by a law of our nature antecedent to experience. The rays of light pass to the retina on optical principles; but we know not in what way impressions are made on the mind. It may be added, that the eyeball is of a commodious size, serving the purposes of distinct vision, and yet not exposing a large surface to the injuries to which such a delicate organ is liable. All the objects in the large field which the eye takes in are accurately represented on the retina. The whole scenery of some miles is painted on a canvass of an inch diameter; and yet how distinct and correct is the picture! This circumstance bears a strong testimony, not only to the existence, but also to the wisdom and goodness, of the Creator.

VI. The motions of the eye cannot fail to attract the notice of every attentive observer and inquirer. These motions are performed by the action of six muscles, four of which are straight, and two oblique. [Pl. V.] The straight muscles elevate or depress the eye, turn it in towards the nose, or out towards the temple; the oblique muscles perform the more complex motions. The origin and insertion of those muscles, and their comparative strength, are fitted with the most consummate mechanical skill for turning the eye in all directions, with the utmost ease and rapidity; and if the nice adaptation of means to the accomplishment of an end be a proof of design, the muscles of the eye demonstrate the existence of a designing cause.

VII. Nor should we pass unnoticed that most delicate and exquisite contrivance, the *nictitating membrane*, discovered in the eyes of birds, and of many quadrupeds. [Pl. III. fig. 2, 3, 4, 5.] Its function is to moisten the eye, to protect it from external injuries, and yet not entirely to exclude the light when covering the pupil. How compact its folds, as it lies unfelt in the outer angle of the eye, and capable, in an instant, of being spread out! Its own elasticity—a peculiarity of this muscle—forces it into its hiding-place as soon as the force is removed which expands it. This membrane is connected with a muscle in the back part of the eye, by a very small tendon, so as not to obstruct the light sensibly, even when it passes over the pupil. By the voluntary contraction of this muscle the membrane is drawn over the front of the eye; and when this contraction ceases, the elasticity alone of the membrane brings it back again to its usual position.

The muscle which is attached to the nictitating membrane is connected with a very singular piece of mechanism. It passes through a loop formed by another muscle, so as to possess all the mechanical convenience of the movable pulley, at the same time allowing a greater length to the muscle than could be admitted into the space allotted to it in the back part of the eye. [Pl. V.]

From this cursory view of the eye, it obviously appears to be an organ of most exquisite workmanship. Its numerous parts are adapted to each other with the most skilful contrivance and minute precision, and the whole serves the noblest and most beneficial purposes. Take the eye altogether,—its position; its ingenious and accurate construction as an instrument of vision; its instantaneous adjustment of itself to different distances; its capacity of accommodating itself to different degrees of light; the ease, rapidity, and variety of its motions; and the provision made for keeping it clean and safe,—and it plainly demonstrates the existence of an intelligent first cause. I hesitate not to affirm, that, although there were not another mark of design in the universe, yet the appearance of even a single eye would be an irrefragable evidence of a designing cause; for nothing that we either see or know; nothing in our own experience, or in the authenticated testimony of others; nothing resulting from consciousness, perception, or reasoning, gives us the least ground for believing that even a single eye could be formed in millions of ages, by any casual combinations of matter. Every eye, then, bears a strong testimony to the existence of a wise designing cause.

But supposing that one eye might have been produced by casual combinations, how shall we account for the appearance of a second? There is just as much difficulty in accounting for the second as for the first, and as much difficulty in accounting for the third as for the second, and so on for every eye that is in the universe; for the existence of one eye is neither a necessary nor a physical cause of the existence of another, and it is not in the nature of chance to establish a series. There are, then, as many distinct witnesses of the existence of an intelligent first cause as there are eyes in the world. And let me add, that it is a most unphilosophical subterfuge to allege that one being with eyes has produced another being with eyes, and that the series has gone on from eternity. This can be considered only as an acknowledgment, on the part of the atheist, that he knows nothing of the matter, and as a silly attempt to plunge into darkness and conceal himself from pursuit. But, go where he will, he cannot escape from the difficulty. Every step that he retires, it still presses upon him. It pursues him through eternity, and every moment treads on his heels, with the same force as in the first instance. Still a voice sounds in his ear, "Here is design—where is the designing cause? Here is contrivance—where is the contriver? Point out the planning mind; show the hand that with such dexterity has adapted means to the attainment of an end." Go where he will, he has not accounted for the first eye; he has not accounted either for the origin or continuation of the series; and in no way can they be accounted for, but by the admission of a powerful, wise and good first cause.

We give much credit to the artist who makes a few good instruments. The fame of Dollond, as an optician, is high, and not undeservedly so; although causes over which he had no control contributed to aid his genius and exalt his fame; for we are told that the glass employed by him in the construction of his best telescopes was a fortunate treasure, all of one melting. But what should we have thought of his genius and art, if he had made telescopes which produced other telescopes, of undiminished excellence, through an unlimited series? We should have pronounced them above all encomium. What, then, shall we say of Him who formed the eye, and established the law by which a vast succession of eyes is generated? Must not *He* be a designing Being? Must He not be unspeakably powerful, wise, and good? If I were brought into a court, before an enlightened jury, where I should lose my cause unless I could adduce some plain mark of intelligence and design in the works of nature, I should boldly contend, after bringing forward the human eye, with all its apparatus, that I had made good my cause, and should confidently expect a verdict in my favor; and such a verdict any jury competent to decide upon the subject would assuredly return.

How the eye conveys sensation to the mind, I cannot tell. If in this there be mechanism, it is such a mechanism as eludes our notice and defies our investigation. All sensation is conveyed to the mind by an unknown influence of the nerves. If the optic, or any other nerve distributed to an organ of sensation, be cut or rendered paralytic, the animal instantly loses that particular sense. The fact is fully established by observation and experiment. But how the nerves, which are perfectly similar in every part of the body, should convey to the mind feelings so different, when distributed over the eye, the ear, the tongue, and the nose, is what we can neither understand nor explain. Here reason and philosophy are set at defiance. Indeed, in every thing around us, we may proceed a certain length with success in our inquiries; but we soon reach a limit which neither our industry nor ingenuity can pass. We perceive an end accomplished; but *how*, we are often unable fully to explain. Some parts of the process elude our utmost penetration, and on those parts we can pass no judgment. But a good effect is produced. The means, so far as we can trace them, are admirably adapted to the end. In such circumstances, it is truly characteristic of a *fool* to condemn the whole, because he can understand and explain a part only; or to deny design, because he cannot fully trace the mechanism throughout the whole process.

The organ of hearing is no less strikingly, and probably no less mechanically, adapted to its office than the eye. It consists of an external ear (the *concha*), contrived like an ear-trumpet, to collect the pulsations of sonorous bodies. [Pl. IV. fig. 1.] In larger animals, there is the power of moving the axis of the external ear towards the direction of the sound. From the concha proceeds a tube, across which, within the head, there is drawn a very thin, elastic membrane, called that of the tympanum, or drum of the ear. Connecting the drum with the interior channels and recesses of the skull, is a chain of curious and delicate bones. [Pl. IV. fig 2.] These recesses are spiral in form, and resemble wind instruments of music. [Fig. 3.] From the tube within the membrane of the tympanum proceeds the eustachian tube, which enters the back part of the mouth. The object of this is, undoubtedly, to supply the inner ear with air, so as to save the drum from injury from the external pressure. Here, then, is evident wisdom and design. Aerial pulsations, concentrated by the involutions of the concha, vibrate the membrane of the tympanum. This acts upon the chain of bones before mentioned, and these convey to the brain the sensation of sound.

The texture of the membrane of the tympanum is so extremely delicate that it can be discovered only in very large animals. That of the Elephant has its muscles radiating from the centre, and which is probably the case with that of all animals. This seems to be done in order to bring it in unison with different sounds. [Pl. IV. fig. 4.] This wonderful adaptation to the purpose evidently designed, is worthy our high admiration.

CHAPTER III.

GENERAL VIEW OF THE HUMAN BODY.

We might now proceed to the organs of the other senses, and show that in them there is a wise adaptation of means to the attainment of beneficial ends; and that design plainly appears in the senses of smelling, tasting, and feeling. We might also consider the different members of the body; as the hand, which Aristotle pronounced the "organ of organs." Its excellence depends in no small degree on the position, strength, and action of the thumb, which can be brought into a state of opposition to the fingers, and hence is of great use in laying hold of bodies. [Pl. VI.] We might also show that the foot is well fitted for the support and progression of the body, and exhibits a noble display of benign intention and skilful contrivance. But instead of entering on such an extensive field, we shall merely take a general view of the human body.

The bones, amounting, in a full-grown person, to about two hundred and forty, constitute the frame of the machine; and in order to retain them in their places, and enable them to perform their several functions, they are strongly and ingeniously bound together by elastic ligaments, membranes, or muscles, according to the several situations and uses of the parts. Some of the joints have a free, easy, and obvious motion; while that of others is less evident. In the joints, the articulating surfaces, being exposed to friction, are lined with a smooth, elastic substance, named cartilage, which is lubricated with *synovia*, as the wheels of machinery are with oil. Now, if the oiling of the axles of machinery be the effect of design, we think it unreasonable to deny design in the lubrication of the joints.

The articulations of the several joints are very different, and, in every instance, are happily suited to their places and purposes. Let us, for a moment, glance at the *spine*. [Pl. VIII.] How different is its formation from that of the thigh bone, and its articulations from that of the hip, knee, or ankle joint! [Pl. VII.] And is not design, are not wisdom and goodness, obvious in the structure of each, and in the difference between them? Had the spine been formed of a single bone, like the thigh, it would have been much more easily fractured than at present, and utterly incapable of incurvation. Had it consisted of only two or three bones, articulated like the hip or like the knee joint, the spinal marrow would have been bruised at every joint, and the motion could not have been so free, nor the pillar so strong as it is. The spine consists of twenty-four pieces, called *vertebræ*, with cavities and protuberances for locking into each other, so as to prevent luxation, and yet provide for the flexion of the body. The spinal marrow, which is of essential importance to life, is lodged in the cavity secure from injury; and corresponding notches in the vertebræ leave a passage for the entrance of the blood-vessels, and for the departure of the nerves, which proceed from the spinal marrow to the different parts of the body.

This bony column, which thus affords a canal through which the spinal marrow, the production of the brain, proceeds in security towards the extremities, also supports the head [Pl. IX.], where the brain, the throne of sensation, motion, and intellect, is lodged in the *cranium*, as in a fortress skilfully and artificially constructed; and the organs of seeing, hearing, smelling, and tasting, are placed like so many watchmen on the walls, while the sense of feeling is diffused over the whole body. The spine also serves to connect the framework of the body. [Pl. X.] In short, let any person attend to the way in which the different bones are united, and consider how both their forms and articulations are varied and adapted to different situations and offices, all advantageous to the strength and motion of the frame, and he will feel himself constrained to admit the existence of a wise designing cause.

If the bones evince intelligence, gracious design, and skilful contrivance, the muscles and tendons also bear testimony to the being of God. The muscles act by contractions and relaxations; and the insertion, the action, and strength of each, are nicely proportioned to its place and office in the body. [Pl. XXVI.] The action of most of the muscles is subject to the will; and, at pleasure, we can put them in motion, or allow them to remain in a state of rest. This, indeed, is not the case with them all; but design, and wisdom, and goodness, are equally obvious, whether their action be voluntary or involuntary.

Several motions and processes go on within us, without any volition on our part. The action of the heart and of the lungs, the circulation of the blood, the digestion of the food, and the various secretions, go on when we are asleep as well as when we are awake, and do not depend on the will. This is a wise and gracious provision, for these motions and processes are necessary to life and health; but, if these nice and complicated movements had been dependent on the will, they must have occupied much of our attention; in many instances, they must have been but partially performed; and in sleep, they must have been neglected and suspended. Therefore, by a wise appointment, these vital motions are involuntarily performed. But other motions depend on the will, and in them wisdom and goodness are as conspicuous as in those that are involuntary. At pleasure we can open our eyes to see the light, or shut them on the approach of danger: we close them involuntarily in sleep. By an act of my will I can speak or be silent; rise up or sit down; walk or stand still.

The body is nourished by the blood, which, flowing from the heart as the fountain, like a genial and fertilizing stream, conveys life and nutriment to the whole system. The heart is a hollow muscle, of a conical shape, which involuntarily contracts and relaxes more than sixty times in a minute, and acts as a forcing-pump to propel the blood through the arteries. It consists of four distinct cavities. The two largest are called *ventricles*; the two less, *auricles*. The right ventricle, by its contractions, propels the blood, by the pulmonary artery and its numerous ramifications, through the lungs, where it is every moment undergoing a great change, giving out carbonic acid, and taking in oxygen—a process essential to life. The blood, on leaving the lungs, passes into the left auricle, and thence into the left ventricle, which propels it through the proper arteries, to carry the vital aliment through every part of the system [Pl. XI.].

But the circulation is not effected by the propulsive action of the heart alone. It is aided by a peristaltic motion in the arteries, which have a muscular structure, and are much stronger than the veins, through which the blood is conducted back to the heart. Both the arteries and veins are furnished with valves. Those of the arteries are situated where these vessels issue from the heart, and are so constructed as to allow a free passage of the blood from the heart towards the extremities, but to prevent its return by the same channel. In the veins, the valves are so formed as to permit the blood to flow freely from the extremities towards the heart, but to hinder it from moving in the opposite direction. These valves are most numerous in the small branches, where the impetus of the blood is least. In the structure of the valves of the blood-vessels, design and contrivance are obvious. It was by attending to this circumstance that Harvey* was led to the discovery of the interesting fact of the circulation of the blood, by which he has acquired a lasting celebrity. Can it then be imagined for a moment, that the peculiar structure of the arterial and venous valves, by observing and reasoning on which that distinguished physician was led to the discovery of a great fact in nature, happened without design and skilful contrivance? This imagination cannot be entertained but by the stupid credulity of atheism.

The blood, sent from the left ventricle of the heart, and conveyed through the system by the branches and capillary ramifications of the arteries, returns by the veins. The arteries, in proceeding from the heart, branch out and become smaller and smaller; and the veins, in advancing towards it, gradually unite and are enlarged, till the whole of those returning channels, by reiterated unions, are formed into one large trunk, through which they pour their contents into the right auricle of the heart. The blood, having thus completed the circulation, instantly sets out again on its tour, to discharge, in passing through the lungs, those portions which are noxious, and convey fresh nutriment through the body. The blood-vessels are so wonderfully ramified, that scarcely a spot can be punctured but the blood will appear.

The whole of the blood, however, does not perform this circulation. The ultimate ramifications of the arteries, in many instances, are so minute as not to afford a passage to the red parts of the blood, but transmit the thin and pellucid part of it only; and those ramifications, instead of communicating with the veins, lodge their contents in bones, muscles, ligaments, and other parts of the body, where, by another part of the inscrutable process of *assimilation*, this fluid is converted into a substance of the same specific character and properties with the parts to which it is conveyed. On seeing corn, fruit, herbs, and roots, in the various stages of their growth, who would imagine they could be changed into blood,

* A physician of London, and liberal benefactor of the Royal College of Physicians. His curious and wonderful discovery produced an astonishing revolution in the practice of medicine; and hence many claims have been instituted to the fame and honor which belong to Harvey alone. It is the opinion of some that Hippocrates was the original discoverer of the circulation of the blood, and that Harvey merely has the honor of reviving the knowledge of the fact of the circulation.—*See Dr. Coxe's Vindication of Hippocrates, Philadelphia,* 1834.

and flesh, and bones? The process carried on in this secret laboratory eludes our investigation; but it indicates the hand of a wise and mighty Chemist, who constituted the wonderful apparatus by which the surprising change is accomplished, and endued all its parts with a suitable activity. Besides, these minute vessels pour their contents into all the cavities, and into the glands, where they are afterwards changed into fluids of different qualities, and which answer different purposes. Some of the glands prepare a fluid for lubricating the joints, and the parts in motion; some furnish fluids to promote digestion, and to assist in the preparation of aliment; and some yield a fluid to protect the skin, and to preserve it in a proper state for performing its several offices.

But the whole contents of these capillary arteries which wander from the circulation, cannot be allowed continually to accumulate in the bones, muscles, and other parts to which they are conveyed: accordingly we meet with a set of vessels, which, on account of the transparency of the fluid which they contain, are called *lymphatics*. They begin from surfaces and cavities in all parts of the body as absorbents; and, like the veins, they form, by the union of many smaller vessels, large tubes, and terminate in two trunks, which empty their contents into the veins a little before the veins enter the heart. Thus the lymphatics throw back into the circulation those particles which are no longer of use in the system. What is unfit to be retained in the circulation is carried off by vessels which open externally upon the surface of the skin, or on the internal surface of the lungs, or in the kidneys and intestinal canal. By these outlets, by perspiration, by exhalation from the lungs, &c., every thing unfit for remaining in the system is drained off.

The lungs, which are so essential to life, consist of different lobes, and are composed of a great number of membranous cells, and of numerous ramifications of blood-vessels, nerves, and lymphatics, all connected by cellular substance. The cells, which constitute the greatest part of the bulk of the lungs, are irregular in their shape. They are very small, and have been estimated at a fiftieth part of an inch in diameter. The number of them is very great; but neither their number nor dimensions can be accurately determined. It is evident, however, that in extent they greatly exceed the surface of the body.

The cells are closely connected, and freely communicate with each other, but have no communication with the cellular substance which unites and strengthens them. From the cells there arise small hollow tubes, called *bronchiæ*, which are enlarged by gradual junctions, till, at the upper part of the thorax, all the tubes on each side unite in one; and the two branches joining together form the windpipe. The numberless ramifications of the pulmonary artery and vein are spread over every part of the cellular substance of the lungs, and carry the circulating fluid throughout the whole of those spongy bodies, so that the blood in the vessels and the air in the cells are brought into such a state of contiguity that they can act on each other. Each of the ribs is movable between the bodies of the vertebræ with which it is connected; and the breast bone, by its connection with the ribs, partakes of their motion; consequently the cavity of the chest, in which the lungs are lodged, is susceptible of considerable dilatation and contraction; and these changes in its dimensions are much assisted by the contractions of the diaphragm, or by the action of the abdominal muscles pressing the bowels upwards. Anatomical minuteness is not the object of the present treatise, and therefore what has now been said may suffice for a general account of the organ of respiration; and the structure and functions of this organ exhibit decisive evidence, not only of design, but of admirable contrivance also.

An animal which has once respired cannot exist without the continuance of the process. Some animals need more atmospheric air, some less; but none can live long without it. The assertions that can be opposed to this fact are few and doubtful. We have been told of serpents and worms that have been found alive in the heart of stones, and of toads enclosed in trees and rocks. But, admitting this, it is obvious that there must have been some communication between the external air and the bed of the animal. Air insinuates itself into the cell constructed by the mason-bee for the lodgment of its eggs, although that cell seems hermetically sealed; and there is every reason to believe that it likewise penetrates to the animal embedded in a rock or tree. Experiment shows that this is not mere supposition, for the toad expires under the exhausted receiver of an air-pump; and, if put into a vessel large enough to contain it with ease, but which is hermetically sealed, it does not long survive. The frog leaps away wanting its head or its heart, and it survives the loss of the greater part of its spinal marrow. Eels and serpents can move for some time even after evisceration. Snails and chameleons can live long on air alone. But the life of all animals is soon extinguished on the exclusion of air.

Such is the fact in nature; and accordingly, every animated being, in one way or another, can imbibe or absorb atmospheric air. What is the provision made in man for the accomplishment of this essential purpose? He has lungs, consisting, as we have already seen, of a vast multitude of communicating cells, for the reception of the air; and by means of them that invisible fluid is brought into such a state of contiguity with the blood that they can act upon each other; and by a process, which the present state of our knowledge does not enable us fully to explain, the blood extracts a vital nutriment from the air, or the air carries off a deleterious substance from the blood, or both. The lungs instantly expel the portion of air that has thus discharged its office, and take in a fresh portion to pass through a similar process. This inspiration and expiration are essential to human life. It may be added that while air thus taken into the lungs supports life, if it be thrown into the vascular system, it quickly brings on agitation, convulsions, and death.

It is now a well-known fact that atmospheric air is not a homogeneous fluid, but consists of three different gases, called oxygen, nitrogen, and carbonic acid, which, though of different specific gravities, are always found together; and an atmosphere thus constituted is the best fitted for supporting animal and vegetable life. The lungs did not form the atmosphere, nor did the atmosphere create the lungs, yet the organ of the body and the external element are admirably adapted to each other; the lungs to bring the air into a state of contiguity with the blood, and the blood and air to exercise a reciprocal action. There is always a large proportion of blood in the lungs, and consequently in a state of contiguity with the air in the cells. The blood performs a complete circulation in a short time, and during that space the whole of it passes through the lungs.

It is not long since respiration was in any degree understood, and still there remains much room for investigation and discovery. But we know that the air undergoes a great change in the lungs, and produces a remarkable effect on the blood. Air does not issue from the lungs in the same state in which it entered them. Its quantity is somewhat diminished; it has lost a portion of its oxygen, in the room of which it has gained about eight *per cent.* in bulk of carbonic acid, thrown out probably from the exhalent vessels of the lungs; and it is loaded with aqueous vapor. Besides, it is a well-known fact that arterial and venous blood are not of the same color. The blood has more of a vermilion redness on leaving the heart to proceed in the circulation than on its return to the right ventricle. This change of color is produced in the lungs, and is occasioned perhaps by the ejection of carbon, and the absorption of the disengaged caloric of the oxygen that has disappeared in that organ. Whatever theory we adopt with respect to respiration, whether we consider it as acting by absorption or exhalation; as the means of imparting a vital nutriment, or of carrying off something which, if allowed to remain in the system, would almost instantaneously extinguish life; or whether we combine these notions, —in any case, we see a grand purpose accomplished. We clearly see the end, although the physiological process be not fully understood.

Respiration is likely the chief cause of animal heat, for the temperature of arterial blood is higher than that of venous; the temperature of the left side of the heart than that of the right; and the temperature diminishes as the distance from the heart increases. That atmospheric air contains a considerable portion of caloric is no hypothetical assumption. It can be demonstrated; for air, when rapidly compressed, gives out both light and caloric; and an instrument has been constructed for procuring fire by this process. It is probable that the portion of oxygen gas which disappears in respiration is converted into the carbonic acid which is thrown out of the lungs. But the specific caloric of this last is greatly inferior to that of the former; consequently a large quantity of heat is set free in the lungs when the conversion of gases takes place.* This liberated heat passes into the blood, and is given out by it in the circulation. Thus a quantity of caloric is disengaged in the lungs in every respiration, and by means of the blood is diffused throughout the body, warming and enlivening it. What wonderful adaptations are here presented! What a gracious provision for supporting human life!

* Arterialization, however, will not account for the entire phenomenon of animal heat. The influence of the nervous system over its development is undoubted, though physiologists are not agreed as to the mode by which it operates. Its action may be either direct or indirect; that is, the nerves may possess some specific power of generating heat, or they may excite certain operations by which the same effect is occasioned. It is far from improbable, that the nerves act more by the latter than the former mode; that the infinite number of chemical phenomena going on in the minute arterial branches during the processes of secretion and nutrition—processes which are entirely dependent on the nervous system—are attended with disengagement of caloric.—*Paxton.*

There seems to be a correspondence between the respiration and comparative heat of different animals. The temperature of fish which oxydate the blood by gills, is not much above that of the surrounding medium. In man, the ordinary temperature near the surface of the body is about 96° Fahrenheit; and in most of the *mammalia* it is somewhat higher. In birds, the lungs of which are differently constituted, and much larger in proportion to the size of the animal, the temperature is still higher than in the mammalia. We may add that birds are exceedingly delicate as to air, and die in air where a mouse lives without any perceptible inconveniency.

In respiration we have both the planning and the execution of an extensive and complicated process. We see wonderful combinations and adaptations in order to the accomplishment of a beneficial end; and, by the constitution of our minds, we are constrained to acknowledge design and skilful contrivance in the combinations and adaptations.

In connection with respiration, we may take notice of the voice and the faculty of speech. The principal organ of the voice is the larynx [Pl. XII.]: if it be injured, the air passes through the windpipe without emitting any sound. Besides the larynx, the organs of speech are the tongue, palate, and teeth. With what promptitude does the tongue obey the understanding and will, and communicate a vast variety of impulses to the air! Alphabetical writing, in which we paint sounds, and express all our thoughts by the varied combination of a few arbitrary signs, is justly accounted an astonishing invention. It is a brilliant display of design and skilful contrivance. But is not that combination of organs by which we readily utter such a variety of articulate sounds far more wonderful? How great is that wisdom which formed the organs of speech!

The continual drain by perspiration, and otherwise, requires a constant supply. This supply is bountifully furnished by nature around us; appetite tells us when it is needed, and what quantity is sufficient, and we are provided with a wonderful apparatus for its reception and elaboration. Let us, then, take a cursory view of the intestinal and alimentary canal. The food is received into the mouth, and masticated by the teeth. Now, the food does not make the teeth, but the teeth are evidently formed for the mastication of the food. They are also of importance in aiding the articulation of the voice. Infants, for whom a liquid aliment is provided, and who have not acquired the use of speech, have them not; but they make their appearance when they are wanted. [Pl. XXV.]*

The organs of taste are stationed in the mouth, with those of smelling in their vicinity, to warn us against the admission of any thing noxious into the stomach; and these senses, when they are not vitiated by unnatural habits, are not only faithful monitors, but sources of much enjoyment. Are there no marks of intelligence, design and contrivance, in fixing the teeth just where they are needed, and in the only place where they can be useful? Is there no wisdom and no benignity in guarding the avenue to the stomach, not only by the eye, which inspects every substance presented to the mouth, but also by the organs of smell and taste, posted at the very entrance of the alimentary canal, to detect every thing unwholesome in the food which may have escaped the vigilance of the eye? No man in the right use of reason can affirm it.

In tracing the food in its progress, the marks of gracious design and skilful contrivance still accompany us, and multiply as we proceed. The *trachea*, or windpipe, the upper part of which is called the *larynx*, communicates with the *œsophagus*, or passage to the stomach. If the minutest part of our food pass into the trachea, it never fails to produce a violent cough, and sometimes very alarming symptoms. This accident, however, seldom happens. How is it prevented? By a very simple but skilful contrivance. A neat, elastic, cartilaginous lid, called *epiglottis*, is so attached to the mouth of the windpipe as to be pressed down by the food, which it prevents from passing towards the lungs, while the passage to the stomach remains unimpeded. At the same time, the *velum palati*, drawn backwards by its muscles, closes the openings of the nose, and of the eustachian tubes, and so prevents the food from returning through the nose, which sometimes happens partially in drinking. Moreover, in the act of deglutition, the larynx, which, being composed

* Amongst the vessels of the human body, the pipe which conveys the saliva from the place where it is made, to the place where it is wanted, deserves to be reckoned among the most intelligible pieces of mechanism with which we are acquainted. [Pl. XVII.] The saliva, we all know, is used in the mouth; but much of it is manufactured on the outside of the cheek, by the *parotid gland*, which lies between the ear and the angle of the lower jaw. In order to carry the secretion to its destination, there is laid from the gland, on the outside, a pipe about the thickness of a wheat straw, and about three fingers' breadth in length, which, after riding over the *masseter* muscle, bores for itself a hole through the very middle of the cheek, enters, by that hole, which is a complete perforation of the *buccinator* muscle, into the mouth, and there discharges its fluid very copiously.—*Paley.*

of cartilaginous rings, in its ordinary state compresses the œsophagus, is carried forwards and upwards by muscles destined for the purpose, and consequently dilates the opening of the gullet. On reaching the gullet, the food is carried down by the principle of gravity; and a mechanical contrivance also lends its aid. The muscular fibres of the œsophagus contract from above, and press the aliment forward to the stomach. This is obvious in drinking with the head downwards, when deglutition can be performed by the muscular action of the œsophagus only.

The food soon reaches the stomach, a membranous bag, or dilatation of the alimentary canal [Pl. XIII.], where it is accumulated and undergoes new processes. In its process towards the stomach, the food is broken and divided by the teeth, and attenuated by the saliva, a powerful solvent. On reaching the stomach, it is subjected to the operation of a new chemical agent, the *gastric juice*, a liquid secreted chiefly by that organ. The nature of this liquid is not yet fully known. Its taste, color, and solvent powers, are different in different classes of animals. Some living creatures cannot digest that which is the food of others. Some animals, such as sheep, live wholly upon vegetables: their stomachs do not digest animal substances. Others, as the eagle, feed entirely on animal substances: their stomachs do not digest vegetables. Hemlock is poisonous to man; but goats eat it without injury.

The gastric juice does not continue always of the same nature, even in the same animal. It is in some measure modified according to the age, the health, the habits, and the different aliments on which the animal subsists. Sick persons and children are incapable of digesting the food which is nutritious to a healthy man. Some graminivorous animals may be brought to live on animal food, and to reject grass; and some carnivorous animals may be accustomed to vegetables. But still the gastric juice, although it in some measure accommodates itself to the substances subjected to its operation, evidently appears to have peculiar qualities in certain classes of animals. In the dog, it dissolves hard bones, but, in equal times, makes no great impression on potatoes, parsnips, and other vegetable substances. On the other hand, in the sheep and ox, it speedily dissolves vegetables, but makes little impression on animal bodies. Different tribes of animals are distinguished by their gastric juice as well as by their external form, and both are well suited, in every instance, to the habits of the creature; for in many cases there is an astonishing correspondence between the teeth and that liquid. The teeth of graminivorous animals are differently formed from those of the carnivorous tribes; and in both they are wonderfully suited to the food and to the gastric juice of the animal. He who can believe that all these adaptations are the result of chance, is no enemy to credulity.

The gastric juice, while it dissolves food, even although enclosed in perforated metallic tubes, spares the living stomach. But, when life ceases, this liquid often acts on the very organ from which it has been secreted. It differs from a chemical solvent, in having an assimilating power, by which it reduces all substances, whether animal or vegetable, into a soft, pulpy mass, named *chyme*, and prepares them for passing from the stomach into the intestines. If the food has been properly digested in the stomach, on reaching the lower orifice of that organ, named *pylorus*, it is freely allowed to pass. But if it is not fully reduced to chyme, then, by a sort of instinctive sensibility of the pylorus, it is thrown back into the stomach to undergo more thoroughly the action of the gastric juice. In the intestines, the chyme is mingled with the bile and pancreatic juice. In short, from one extremity of the alimentary canal to the other, fluids are perpetually flowing into it from the glands and other sources. By the action of these fluids, and of the intestines, the chyme is formed partly into *chyle*, which is absorbed by the *lacteals*, and thrown into the circulation, and partly into excrementitious matter, which is ejected. [Pl. XXVII.]

Here, then, we see an astonishing process carried on by the instrumentality of many different parts, all nicely adapted to each other, all coöperating in the same work, and tending to the accomplishment of the same end—the support and nourishment of the body. The mastication and deglutition of the food, and the moistening of it with the saliva before it enters the stomach; the great change which it undergoes in that organ, chiefly by means of the dissolving and assimilating action of the gastric juice; the changes induced upon the aliment after it passes from the stomach; the separation of chyle from the excrementitious part; the absorption of the chyle by the lacteals, which throw it into the blood; the mysterious process of assimilation; the peristaltic motion of the viscera [Pl. XIV. fig. 2., and Pl. XXVII.]; and the mucus which is continually secreted for their protection against the acrimony of their contents,—these, when all taken together, exhibit an astonishing process. They furnish an undeniable

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proof, not only of design and admirable contrivance, but of great benignity also. What an amazing structure is the body of *Man!* How wonderful the absorbent, the circulatory and secretory apparatus of the human system! We are wonderfully made; and the marks of wisdom and goodness are deeply impressed on every part of our frame.

To sum up all, on this part of the subject, in a few words; let any person contemplate the human body; let him attentively examine the skeleton, the figure and structure of the bones of which it is composed, with their articulations; the muscles, their origin, insertion, strength, and action; the organs of sense, the eye, the ear, the nostrils, the tongue, and palate, and the sense of feeling diffused over the whole body; the structure of the jaws, the stomach, and other viscera; the structure and action of the lungs, and organs of speech;—and if he can retire from the examination without a deep impression of intelligence and design, yea, of wisdom and goodness, in the human frame, there can be but little doubt that his understanding is singularly obtuse, or his heart singularly depraved. Every mind, open to the force of evidence and to the impressions of truth, must join in the exclamation of an ancient sage, "I am fearfully and wonderfully made."

It may here be remarked, that, as food nourishes the body, so sleep refreshes both body and mind. This mysterious phenomenon we are unable to explain; but its periodical return is necessary to life, and by it a beneficial end is accomplished. There is an obvious relation between sleep and the rotation of the earth on its axis. They are harmonious parts of one whole.

CHAPTER IV.

THE INFERIOR ANIMALS.

Man is evidently the noblest inhabitant of the earth. He is not, indeed, so strong as the elephant, nor so swift as the antelope: his eye is not so piercing as that of the eagle, nor his sense of smell so exquisite as that of the dog: but the high faculties of his mind give him superiority and dominion over the whole animal creation. Around us we see a vast variety of objects, possessing very different qualities. These objects do not stand at a great distance from each other: they are wonderfully linked together, rising above each other by almost imperceptible degrees. The system of nature is a system of insensible gradations. The two extremes of organic and inorganic matter, perhaps, meet at a common point. Corals and corallines seem to unite the mineral, vegetable, and animal kingdoms. The boundaries of animal and vegetable life are obscurely defined, and the interval between the polypus and man is filled up with an amazing gradation of animated beings. The progress from unorganized to organized matter, from vegetable to animal, and from animal to rational existence, presents an astonishing and gradually-ascending series. In the whole progression we see a striking uniformity of plan, with a rich variety in the execution: beautiful analogies and nice distinctions every where occur.

It is animal existence which, at present, claims our attention. The earth, the air, and the water, are all abundantly replenished with sentient beings, differing in their external appearance, their habits, and their dispositions; and all enjoying happiness according to their several constitutions. Man, unquestionably, stands at the head of this system of animated being; and there seems to be a much larger interval between him and the most sagacious of the inferior animals, than what occurs in any other part of the gradation. It is true, indeed, that, in a number of instances, we find man in a state little superior to that of the brutes; but, in the view under consideration, we must take his capacity of improvement into our estimate. My full conviction is, that if we were to examine animals, in every gradation from the polypus to man, we should meet with incontrovertible evidences of design, and wise and benevolent contrivance, in every stage of our progress. But a field of this kind is greatly too extensive for our present purpose. It would be, no doubt, both pleasant and instructive leisurely to pass through the whole animal kingdom, and to examine with minute attention every thing that fell in our way. This, however, would lead into voluminous details, instead of a concise treatise. My limits confine me to a few remarks; and as neither comparative anatomy nor natural history is my object, I shall pay no attention to systematic arrangement, but shall endeavor to show,

I. That the form of the inferior animals is admirably adapted to their manner of life;

II. That they are provided with suitable clothing;

III. That they possess means of defence suited to their condition;

IV. That they are qualified for procuring their food;

V. That we meet with surprising adaptations of animals to peculiar circumstances.

Under each of these heads, I shall mention a number of particulars respecting the inferior animals: these particulars will be of a very miscellaneous nature, but, I presume, will all tend to show wise design and benevolent contrivance in nature.

I. The form of the inferior animals is admirably adapted to their manner of life.

1. In the form of the different kinds of quadrupeds there is great variety; but amidst all the variety we perceive the same general plan; the same great outline appears in the skeleton, in the articulations of the bones, in the disposition, form and insertion of the muscles; and in several other circumstances, all accommodated to the peculiar nature and habits of the animal. The organs of sense, of digestion, and of circulation, occur in all the species, but are varied according to the destination of each.

In order to support the head of quadrupeds, they are furnished with a very strong ligament, firmly bracing the head to the vertebræ of the back. This ligament arises from the spines of the dorsal and cervical vertebræ, which are lengthened out for that purpose, and is fixed to the middle and posterior part of the occipital bone. It is of great strength and size in all quadrupeds, but is remarkably so in the elephant, where the great weight of the head requires a strong support. This ligament is wanting in man, because he did not need it; but it is of great use to quadrupeds, and they are provided with it. Here, as in every other department of nature, the provision is suited to the exigency of the case.

In graminivorous animals, we see a remarkable correspondence between the length of the legs and the length of the neck. According to the ancient fable, Tantalus was set up to the chin in water, and apples were at his lips; but he had no power to stoop to the one to quench his thirst, or to reach up to the other to satisfy his hunger. There is nothing like this in nature. All animals are capable of gathering their food. Herbage is abundantly provided for the graminivorous tribes, and there is such a correspondence between their necks and their legs that they can easily reach it.

2. The external figure of birds is excellently adapted to the mode of life which they are destined to pursue. They can either walk on the ground, or by the action of their wings rise buoyant on the air, and pass through it with great rapidi-

ty, somewhat like fish in water. Their wings are moved by remarkably strong muscles, and their tail serves as a rudder to direct their course. In most cases, their heads are small. The proper bones of the cranium, at least in adult animals, are not joined by sutures, but are consolidated into a single piece. This small and compact head generally terminates in a sharp-pointed beak; and the breast-bone is formed somewhat like the prow of a ship, so that the bird can pass easily through the air. The wings are placed more forward than the middle part of the body; and, at first sight, we should be ready to imagine that, in flying, the posterior parts would hang down, and that the bird would be unable to preserve the body in a horizontal position. But, by stretching out its head, which acts upon the lever of a long neck, by filling its abdominal *sacs* with air, and by expanding the tail, it alters the centre of gravity, and keeps its body nearly in the plane of the horizon. The legs of birds are placed far back in their bodies; but, by erecting the head and neck, they throw the centre of gravity on the feet. As birds are destined to pass rapidly through the atmosphere, so their internal configuration, as well as their external form, is happily fitted for volitation. They harmoniously conspire for the purpose, and so run into each other that I shall consider them together.

Receptacles of air pervade the whole bodies of birds, and their respiratory organs constitute one of the most singular structures in the animal economy. Their respiration is performed by means of lungs which are fixed to the back-bone, and which have a communication with air cells spread over the whole abdomen, and also with hollow bones, which, instead of marrow, are filled with air. And not the hollow bones only are filled with air, but the pinions also: in some cases, the communication even extends to analogous cavities in the muscles. In those birds which soar highest, such as the eagle, the hawk, and the lark, the cavities in the bones and below the muscles are very large. This great diffusion of air throughout the bodies of birds, makes them specifically lighter than otherwise they would have been, and so fits them for supporting themselves in that medium through which they are destined to pass. If we consider the rarefaction of the included air by the heat of the animal, we will easily perceive that these air cells enable the bird to fly with much more ease than it could have done if it had been formed like quadrupeds.

The air cells seem likewise to supply the place of a diaphragm, and of strong abdominal muscles. Without adding any thing to the weight of the body, they produce the same effect on the *viscera* as those muscles would have done. Probably they are also of much importance to the respiration of the bird. The ostrich, indeed, which does not fly, is provided with them; but from the use which it makes of its wings in running, they no doubt contribute to the rapidity of its motion. The bat has them not; but its structure is peculiar, and its flight is never long. Here we see a conformation of parts evidently fitted to the bird's manner of life. The wings did not form the pointed beak and sharp breastbone, nor did they create the air vesicles; and, on the other hand, the pointed beak and the air vesicles did not give existence to the wings. They exist independently on each other; yet they all harmonize and contribute to the same end. The inference is obvious and irresistible.

3. Of the inhabitants of the water there is a prodigious variety; but one general figure, subject to different modifications, prevails among fish. Their form is well fitted for traversing the fluid in which they reside; and, by means of their fins and tails, many of them can pass through the water with great rapidity. Men, in some measure, imitate the shape of fish in the construction of fast-sailing vessels. But many fishes, with the greatest ease, overtake a ship under sail, play around it as if it were motionless, and dart off before it at pleasure. The tail is the great instrument of progressive motion; the fins serving chiefly to keep the body upright.

Fish are furnished with organs of respiration suited to the element which they inhabit. Instead of lungs, they have gills, or *branchiæ*, which are placed behind the head on each side; and, in most instances, have a movable gill cover. By means of these organs, which are connected with the throat, the animal draws its oxygen from the air contained in the water, as animals with lungs derive it immediately from the atmosphere. Fish discharge the water through the bronchial openings, and thus their expiration and inspiration are performed through different passages. The heart of fish is very small in proportion to the body. Its structure is simple, consisting of a single auricle and ventricle, which correspond with the right side of the heart in warm-blooded animals. The ventricle gives rise to a single arterial trunk, going straight forward to the branchiæ, whence the blood passes into a large artery, analogous to the *aorta*, which goes along the spine, and supplies the body of the animal. It is returned by the *venæ cavæ* into the auricle.

The temperature of the inhabitants of the water is nearly the same with that of the element in which they reside; and fish need less air than hot-blooded animals. Still they need a certain portion of air, and soon expire under the exhausted receiver of an air-pump. Berzelius,* indeed, has stated that a fish may continue alive for several days in water which is void of air, and that it cannot be observed that the least decomposition of the water has taken place by its respiration. But he has not told us whether he means to assert that this takes place under the exhausted receiver of an air-pump, or only when there is a free communication between the water and the atmosphere. A fish lives in a narrow-mouthed vessel filled with water, so long as the communication with the external air remains open; but soon dies if that communication be completely shut up. If a hole be broken in a frozen lake, the fish quickly repair to the place. Hence, in winter, the North American Indians, when their provisions fail, break a hole in the ice, and commonly succeed in obtaining a fresh supply by fishing.†

As fish have no lungs, so we have already seen their heart has only one auricle and one ventricle. Now, the heart did not create the respiratory organs, nor did the respiratory organs form the heart; yet they are evidently adapted to each other. Many fishes are provided with a *swimming bladder* [Pl. XIV. fig. 3.], which lies close to the back-bone, and has a strong muscular coat. The fish can either contract or dilate this bladder, and, rendering itself specifically lighter or heavier, can descend or ascend at pleasure. Flounders, and some other fishes, which want this bladder, are always found grovelling at the bottom of the water. This, however, is not universally the case; for fishes of the cartilaginous kind want air bladders, and yet they easily rise to the top or sink to the bottom; and although most of the eel kind have air bladders, yet they cannot raise themselves in the water without difficulty. It is probable, therefore, that this bladder serves other purposes in the economy of the fish besides enabling it to rise and sink in the water.

* At present professor of chemistry and of pharmacy, secretary of the Royal Academy of Sciences at Stockholm. The king of Sweden, Charles XIV. (Bernadotte), has made him a nobleman. He has enriched the science of chemistry by many important discoveries and profound and elaborate works. He is the first chemical analyst of the age, and has distinguished himself particularly by researches into the laws of definite proportions. Most of his works have been translated into French and English. He was born at Linkioping, in East Gothland, 1779.

† River water has rather less than $\frac{1}{16}$ of its bulk of air. This air contains about $\frac{11}{100}$ of oxygen; from $\frac{6}{100}$ to $\frac{11}{100}$ carbonic acid: the remainder is nitrogen.

The natatory bladder is largest in such fishes as swim with considerable velocity. It is wanting in flat fishes, where the large lateral fins supply its place, and in the shark, where its absence is compensated by the size and strength of the tail. It does not exist in the lamprey, which possesses none of these compensations; and therefore it creeps slowly at the bottom of the water. In fresh-water fishes, the air bladder, according to Erman's experiments, contains nitrogen gas mixed with varying proportions of oxygen gas; but this last is never found in it in the same proportion as in atmospheric air. Biot* found that, in salt-water fishes, it contained oxygen gas, increasing in proportion as the fish was in the habit of living at a great depth.† This bladder communicates generally with the œsophagus, and sometimes with the stomach. The whale tribe, and the web-footed mammalia, which breathe by lungs, must often rise to the surface for the purpose of respiration.

Some of the inhabitants of the water present a singular appearance. Their bones, instead of being placed internally, form their exterior covering. They stand low in the scale of animal existence; but even in them we see a wise and gracious provision for the preservation of the creature. The muscle, for instance, has a locomotive power: on looking at it, we should be apt to imagine that it would be the sport of the waves, and be dashed to pieces against the rocks in a storm. It, however, has the power of securing itself against this danger, and of providing for its safety, by forming certain viscous threads, about two inches long, by means of which it firmly attaches itself to the rock, as by a cable and anchor. Upwards of a hundred and fifty of these cables are sometimes employed in mooring a single muscle. Here we see means of preservation well adapted to the state and circumstances of the animal.

4. In the different classes of animals there is a wonderful adaptation of the organs of sense to the structure of the rest of the body, and to the animal's peculiar manner of life. Of this I shall take the eye as an example.

All animals have two eyes: some insects have more. [Pl. XVI. fig. 8, 9.] In man, the eyes are directed forwards,

* A distinguished natural philosopher and astronomer, born at Paris, 1774. His works, published in 1816, are very valuable contributions to science, as are his occasional communications in the literary journals of France. His discoveries in acoustics are both curious and valuable.

† Between the tropics, Humboldt found in the natatory bladder of the flying fish 0.94 nitrogen, 0.04 oxygen, 0.02 carbonic acid. Some fish inhabiting the lower strata of the ocean have as much as 0.92 of oxygen in their air bladder. —Humboldt, *Personal Narrative*, v. ii. p. 16.

harmonizing with the form and articulations of the upper and lower extremities, and with the configuration of the whole body. In most of the inferior animals, the eye has an oblique direction. The simiæ and the owl look straight forward. The motions of the human eye are performed by six muscles: quadrupeds have a seventh, named, from its office, the *suspensory* muscle. It sustains the weight of the globe of the eye, and prevents the optic nerve from being too much stretched, when the animal is obliged to hold its eyes in a hanging posture, and to look downwards in choosing and gathering its food. In man, on account of his erect posture, this muscle is not needed, and in the human subject it is not found; but to quadrupeds, by reason of their prone posture, it is of great utility, and they are provided with it. Now, the suspensory muscle does not occasion the prone posture of the animal, and the prone posture does not create the suspensory muscle, for it comes into the world with the quadruped; yet the one is adapted to the other. Is there not design, yea, benevolent design and skilful contrivance, in this adaptation?

Many animals, but especially birds, whose eyes are much exposed to injury in passing through woods and thickets, are provided with a somewhat transparent covering for the eye, called the *nictitating* membrane. [Pl. III. fig. 2, 3, 4, 5.] It admits as many rays as render objects visible, and protects the organ of vision in circumstances of danger. It screens the eye when the bird is flying directly against the rays of the sun; and by means of it, according to Cuvier,* the eagle is enabled to look at that luminary. It also serves to cleanse the cornea—an operation which man can perform with his hand. It is drawn over the globe of the eye by the combined action of two very singular muscles, which are fitted for the purpose with much mechanical skill.

The eyes of fish, being much exposed to danger in the inconstant element in which they reside, always have a cuticle, or firm pellucid membrane over them. Indeed, their eyes differ, in several respects, from those of other animals, and are wonderfully accommodated to the medium in which fish exist. The vitreous humor is very small, and the aque-

* A peer of France, perpetual secretary of the Academy of Sciences, professor of natural history in the College of France, and the first naturalist of the age. He was born in Wurtemburg, 1769—a year remarkable as the natal year of Napoleon, Wellington, Ney, Chateaubriand, Humboldt, Castlereagh, and several other illustrious names. His library was purchased by the French government for 72,000 fr. Almost all the learned societies in the world have sent Cuvier honorary diplomas. The Cabinet of Comparative Anatomy, founded by him, affords the finest osteological collection in Europe. He died at Paris, May 13, 1834.

ous sometimes scarcely perceptible. The water, in a great measure, supplies the place of those two humors; but, that refraction may be duly carried on, and vision accomplished, the crystalline is very large, almost spherical, and more dense than in terrestrial animals. In birds these circumstances are reversed; they are often in a somewhat elevated region of the atmosphere, and the rays which pass through that rare medium are refracted by the aqueous humor, which, in birds, is of a large size. Man, and the mammalia, living on the surface of the earth, hold a middle place between these two extremes. The *tapetum*, or mucus which lines the posterior surface of the iris, the ciliary processes, and part of the tunica choroides, is of different colors in different kinds of animals; and in each it is admirably fitted to the creature's manner of life. White reflects the rays of light; black absorbs them. Accordingly the tapetum is either white, or of some vivid color which reflects the light strongly, in those animals which seek their prey by night. The cat and the owl have the tapetum whitish, and the pupil capable of much contraction and dilatation. On the other hand, the tapetum of birds, in general, but especially of eagles, hawks, and other birds of prey, is black; by which means they are enabled to see with the greatest distinctness, but only in clear day light. Man is designed to labor chiefly by day, and his tapetum is neither so black as that of birds, nor so white as that of those animals which make the greatest use of their eyes in the dark. Animals which are much under ground, as the mole and the shrew, have the eyes very small. In the former of these, its existence has been altogether denied; and it is not, in fact, larger than a pin's head. In some reptiles, the common integuments form, instead of eye-lids, a kind of firm window, behind which the eyeball has a free motion.

5. Quadrupeds are divided into the carnivorous and the herbivorous. As their food is different, so a difference in the teeth indicates the class to which the animal belongs. As the teeth of the graminivorous, particularly of the ruminating kinds, are more constantly employed than those of the carnivorous kinds, so they are more thoroughly provided with enamel. There is also a considerable difference in the articulations of the jaws of quadrupeds. In the *feræ*, the articulation admits only of the hinge movement; but in the herbivorous quadrupeds, particularly in the ruminating kinds, the articulation admits of a very free lateral motion. Here there is an obvious correspondence between the form and the habits of the animal.

There is a striking relation between the teeth, and the other instruments of mastication, and the stomach. The sheep, deer, and ox tribes, are destitute of fore teeth in the upper jaw; but the trituration of their food is completed by rumination. The horse and ass do not chew the cud, but they are provided with suitable teeth in the upper jaw for masticating the food and preparing it for the action of the gastric juice. The gastric juice of ruminating animals does not perform its specific operation upon the food till the cud has been chewed; and the animal seems to have as much gratification in chewing the cud as in pasturing. It then appears to be in a state of the most tranquil enjoyment.

Birds have no teeth; but the herbivorous and graminivorous kinds are furnished with the *gizzard*, a powerful instrument for grinding the food, and preparing it for the action of the gastric juice. This juice does not act on the unbroken grain, but the animal is provided with the means of grinding it. Now, the gizzard did not form the bill of the bird, nor did the bill give existence to the gizzard; yet they are exactly fitted to each other. Teeth and a gizzard are not found together.

Instead of extending these remarks, I shall close this section by inserting some of the conclusions of Cuvier, so distinguished by his knowledge in comparative anatomy. "Every organized individual," says he, "forms an entire system of its own, all the parts of which must mutually correspond and concur to produce a certain definite purpose, by reciprocal reaction, or by combining towards the same end. Hence none of these separate parts can change their forms without a corresponding change in the other parts of the same animal, and, consequently, each of their parts taken separately indicates all the other parts to which it has belonged. Thus, if the viscera of an animal are so organized as to be fitted for the digestion of recent flesh only, it is also requisite that the jaws should be so constructed as to fit them for devouring prey; the claws must be constructed for seizing and tearing it to pieces; the teeth for cutting and dividing its flesh; the entire system of the limbs, or organs of motion, for pursuing and overtaking it; and the organs of sense for discovering it at a distance. The shape and structure of the teeth regulate the forms of the condyle, of the shoulder-blade, and of the claws; so that a claw, a shoulder-blade, a condyle, a leg or arm bone, or any other bone separately considered, enables us to discover the description of teeth to which they have belonged; and so also reciprocally we may determine the forms of the other bones from the teeth. Thus, commencing our investigations by a careful survey of any one bone by itself, a person who is sufficiently master of the laws of organic structure may, as it were, reconstruct the whole animal to which that bone had belonged. The smallest fragment of bone, even the most apparently insignificant apophysis, possesses a fixed and determinate character, relative to the class, order, genus, and species, of the animal to which it belonged; insomuch that, when we find merely the extremity of a well-preserved bone, we are able, by careful examination, assisted by analogy and exact comparison, to determine the species to which it once belonged as certainly as if we had the entire animal before us."

II. The clothing of the inferior animals is completely adapted to the climate which they inhabit, and to the different seasons of the year. In Kamtschatka, Lapland, and the higher latitudes of North America, they are clothed with thick and warm furs; but in tropical climates they are almost naked.

The musk-ox, a native of high latitudes, is provided in winter with a thick and fine wool, or fur, which grows at the root of the long hair, and shelters him from the intense cold to which he is exposed in that season. But as the summer advances, this fur loosens from the skin, and by the animal's frequent rolling himself on the ground, it works out to the end of the hair, and in due time drops off, leaving little for summer clothing except the long hair. As the warm weather is of short duration in those high latitudes, the new fleece begins to appear almost as soon as the old one drops off, so that he is again provided with a winter dress before the cold becomes intense. The clothing is suited to the season. Where are the animals found which furnish materials for the fur trade? Not within the tropics; but in countries bordering on the Arctic circle. The elephant is a native of hot climates, and he goes naked. Rein-deer abound in Lapland and in the vicinity of Hudson's Bay, and they have a coat of strong, dense hair. The white bear is found on the coast of Greenland, and his shaggy covering is suited to that high latitude. In a word, if we pass from the equator to Spitzbergen and Nova Zembla, we shall find in all the intermediate degrees, that the clothing of quadrupeds is suited to their climate, and accommodates itself to the season of the year.

Man is the only unclothed animal in all countries; and he is the only creature qualified to provide clothing for himself, and to accommodate that clothing to every climate, and to all the variety of the seasons. In this, as in every other respect, his condition is suited to his nature, as a being whose improvement and happiness are promoted by labor of body and exercise of mind.

If we pass to the clothing of birds, we still find benevolent contrivance, suited to the circumstances and providing for the welfare of the animal. This clothing consists of feathers, which are very bad conductors of heat, and which consequently permit the heat of the animal to pass off very slowly into the circumambient medium. The feathers are so inserted into the skin as naturally to lie backwards from the head, and to lap over each other, like tiles on a roof, allowing the rain to run off.* When the head of the bird is turned towards the wind, the feathers are not discomposed by the most violent storm. There is in birds a large gland, which secretes an oily substance; and when the feathers are too dry, or any way disordered, the bird squeezes the oil out of this gland, and dresses them with it. Thus the admission of water is prevented; and the bird, by means of its feathers, is sheltered both from cold and rain. Water-fowls have their breast covered with warm and soft clothing, suited to their circumstances. The eider-duck abounds on the coasts of Iceland; and the warmth of eider-down is well known. While the feathers of birds thus preserve them from cold, they are also a sort of defensive armor, and excellent instruments of motion.†

The temperature of fish is not much above that of the medium in which they reside; and they have not, in general, any great occasion for warm clothing. Nevertheless, they are provided with a scaly coat of mail, and are covered with a slimy and glutinous matter, which not only defends their bodies from the immediate contact of the surrounding fluid, but probably facilitates their motion through the water also. Under the scales, and before we come to the muscular part

* By the aid of the microscope it appears that the laminæ or threads of feathers have, on their outward edge, a series of bristles, set in pairs opposite one another, which clasp with the bristles of the contiguous laminæ. This is the cause of the surprising adhesiveness observable in the feather or quill.

The bristles are not of the same form on each side of one lamina; the lower tier form a simple and slight curve, while the upper terminate with three or four little hooks, which serve to catch the simple corresponding bristle of the next lamina.—*Paley*.

† The *Elytra* or horny wings of the genus scarabæus, or beetle, is an admirable contrivance, furnishing both a covering and a protection to the delicate gauze-like wings of this insect. In some, the *elytra* envelop the whole body; in others, only a small part of it. In all, they form an entire covering for the true wings. [Pl. XV. fig. 1, 2.]

of the body, we meet with an oily substance, which contributes to the preservation of the requisite warmth. The whale is a hot-blooded animal, and resides chiefly in polar regions; but he is wrapped up in a thick coat of blubber, which is a bad conductor of caloric, and defends him from the cold. Other inhabitants of the water in high latitudes, as the walrus, enjoy a similar security against the rigor of the element to which they are exposed. Can we seriously attend to the clothing of animals, without recognizing in it the hand of a wise and beneficent *First Cause?*

III. Every animated being is endued with the love of life, and the desire of self-preservation; and is also furnished with the means of acting in conformity to this instinctive principle of its nature. Every animal can search for its food, and choose what is proper for its subsistence. But, at present, I shall shortly attend to the means which different animals possess of securing themselves against danger, and of defending themselves from their enemies. Every animal possesses, in a certain degree, the means of self-preservation, either by resistance or flight. Some animals have formidable instruments of offence in their horns, teeth, claws, hoofs, or sting; others trust for safety to the swiftness of their course, or velocity of their flight; and some defend themselves by emitting a repulsive odor.

In gregarious animals, although the individual, in some instances, is weak and timid, yet the herd or flock can assume an imposing attitude, and make a vigorous defence. No creatures are more timid and defenceless than sheep, when under the protection of man. In the natural state, however, the rams, constituting the half of the flock, place themselves in battle array against the enemy, and dogs can make no impression upon them. Even the lion or tiger is unable to resist their united impetuosity and force! A single goat can choose his position on the rock, and set the dog at defiance. Horses join heads together, and fight with their heels; oxen join tails, and fight with their horns; all place their young in the centre, that they may be safe during the battle. In perilous cases, elephants march in troops; the oldest in front, the young and feeble in the centre, those of middle age and mature vigor in the rear. When at a distance from danger, they travel with less precaution, never, however, separating so far but that they can hear one another's cries, and afford timely assistance.

The mole is well-formed for digging [Pl. XVI. fig. 1.], and escapes from its pursuers by penetrating into the earth: the hedge-hog rolls itself up in a prickly envelope: the hare is well-fitted for running, and trusts to its swiftness for safety. The innocuous *lama*, which uses neither feet nor teeth against its enemies, is not destitute of means of defence. It is provided, we are told, with an acrimonious saliva, which, when offended, it can eject to the distance of several yards. This saliva occasions troublesome cutaneous eruptions where it touches.* The viper at once wounds with its fang, and injects into the wound the deadly poison. [Pl. XIV. fig. 4, 5.] Some animals are furnished with peculiar glands and bags at the end of the rectum, which secrete and contain a remarkably fetid substance; and this substance the animal can at pleasure throw out against its pursuers. The *zurilla*, a species of weasel about the size of a rabbit, found in several parts of South America, emits, when angry, such a pestilential vapor as beats off the most formidable adversary. Another inconveniency, says De Pages, which awaits the traveller in this country (between St. Antonio and Mexico), is the abominable smell of an animal, without the agility, but nearly of the size, of a rabbit. This creature, when hardly pressed, and in jeopardy of being taken, emits a most intolerable stench, which threatens suffocation to his pursuers, and which is eluded only by a precipitate flight. The polecat (*Viverra putorius*), when pursued or irritated, forces upon its pursuers a fluid of so horrible an odor that neither man nor dog can endure it.†

* Ulloa, Voyage au Perou, liv. vi. ch. 8. Wilcock's History of Buenos Ayres, p. 458.

† *The tusks of the babyrouessa* [Pl. XVIII. fig. 4.], *or Indian hog, are said to be contrived as a means of defence in suspending themselves from a branch of a tree during the period of their repose, out of the reach of other animals. But "there does not seem to be any sufficient authority for ascribing this use to the tusks of this animal. Indeed, one does not readily see how it could in the way described swing itself clear of its enemies, except by first climbing the tree; which is not pretended. The fact is doubted, it is believed, by many naturalists; and the opinion probably was in the first place founded upon mere conjecture. A modern and distinguished traveller has these remarks upon the subject. 'Philosophers had long puzzled themselves in conjectures what the design of nature could be, as she does nothing without design, in giving to this animal a pair of large, curved tusks, pointing inwards to the face, in such a manner as made it sufficiently clear they could not be used either for attack or defence, for procuring food, or for assisting the mastication of it when procured. At length it occurred, or was discovered, by whom I do not recollect, that the animal is fond of sleeping in a standing posture, and that, having a large, ponderous head, it finds a conveniency in hanging it upon the branch of a tree or shrub within the reach of its tusks, which serve on such occasions for hooks. This is at least an ingenious discovery, and may be true; but if so, the habits of the animal must vary according to local circumstances. The same species, or one so like it that the difference is not distinguishable by any description or drawing that I have seen, is common among the rocks on the deserts of Southern Africa, where, within the distance of a hundred miles, there is neither tree nor shrub, except a few stunted heaths or shrivelled ever-*

Birds, by their different ways of flying, often escape from their enemies. If the pigeon had the same way of flying as the hawk, it could scarcely ever escape his claws.

If, from the earth and the air, we pass to the ocean, we shall find its inhabitants possessing, in like manner, means of defence and safety. The cuttle-fish (*sepiæ*), when closely pursued, ejects a fluid black as ink, and conceals itself and escapes by discoloring the water. The excretory duct is situated on or near the liver. The fluid itself is thick, but so miscible with water that a small quantity of it discolors a considerable body of water. According to Cuvier, the Indian ink is made of this fluid. Some fishes have fins so large and flexible, that, when pursued, they can spring out of their native element, and dart through the air to a considerable distance.*

Some of the inhabitants of the water possess peculiar means of defence, by giving electrical shocks. The electrical fluid is widely diffused in nature; and seems to be lodged, in greater or less quantities, in all animals. That there is a considerable portion of it in the human body is evident. Some persons are naturally so much electrified as to give obvious signs of the presence of this fluid, when a delicate electrometer is applied to them; and if their hair is combed, when they are placed on an insulating stool, they emit sparks. But only a very few animals have the power of giving shocks. So far as is at present known, they are all of the aquatic kind; the *torpedo*, *gymnotus electricus*, and *silurus electricus*.

This property of the *torpedo* has been known since the days of Theophrastus. It has the power of giving a smart shock to the person who touches it. According to Humboldt and Guy Lussac, the contact must be immediate. The shock depends on the will of the animal, which must be irritated before it exerts its peculiar power. The electrical apparatus of the torpedo has some resemblance to a galvanic trough, and seems to act in a similar manner.

The *gymnotus electricus* is a species of eel peculiar to Surinam river, and is said to be a fresh-water fish only. When of the largest size, it is about four feet long, and from

lastings, thinly scattered over the barren surface. In such situations, where I have hunted and taken them, it would certainly be no easy matter for the babyrouessa to find a peg to hang its head upon.' "—Barrow's Voyage to Cochin-China. *Dr. Ware.*

* The velocity with which fish swim from one part of the globe to another is astonishing. When a ship is sailing at the rate of fourteen miles an hour, the porpoises will pass it with as much ease as when at anchor.—*Paxton.*

ten to fourteen inches in circumference in the thickest part of the body. Its electrical power is greater than that of the torpedo. It gives even the most violent shocks without any movement of the head, eyes, or fins. But when the torpedo gives a shock, a convulsive motion of the pectoral fins may be observed.

The *silurus electricus*, a fish about twenty inches long, found in some of the rivers of Africa, gives a shock like the torpedo and gymnotus. By means of this singular power, these animals can stun their adversaries and escape by flight.

Insects appear a feeble race; but some of them possess formidable means of defence and annoyance. Their sting is a spear, which they can wield with dexterity in repelling aggression. [Pl. XV. fig. 5.] The fine polish of this little piece of armor has often been remarked, and adduced as an instance of the difference between the workmanship of the Creator and the productions of art. When viewed through a microscope, the shape of the finest needle seems rough and blunt; but the sting of a bee, when examined by the glass, is seen to be smooth and beautifully polished. The first displays all its beauties to the naked eye; the instrument reveals its deformities: but the beauty of the last appears the more conspicuous the more narrowly it is inspected. In short, every animal is endued, in a greater or less degree, with the means of self-preservation. If any species be singularly exposed to danger, it has the advantage of some great compensating principle, by which it is preserved from extinction. Many of the weaker or more timid animals can elude pursuit by the rapidity of their motions: some are very prolific, and can bear a great waste. Here, as in every other department, we see a uniformity of plan, which can only be the fruit of design; and such an adaptation of means to ends as can result from nothing but benevolent intention.

IV. There is a great variety in the tastes and appetites of different kinds of animals; and there is a corresponding variety in the productions of the earth. There seems to be nothing in the wide extent of the vegetable kingdom, but what will yield sustenance to animals of one kind or other. Each species finds food agreeable to its taste and proper to its nature, and animals of one class cannot deprive those of another of their means of subsistence. According to Linnæus, the hog eats 72 kinds of vegetables; the horse, 262; the cow, 276; the sheep, 387; and the goat, 449. This diversity of tastes, with the corresponding diversity of productions, is one great means of stocking every part of the earth and of the ocean with inhabitants. Some animals, both by sea and land, are found only in certain latitudes. Some dwell in polar regions; others chiefly within the tropics; and each finds its peculiar aliment in the place where it resides.

Animals are wonderfully fitted for discovering their means of subsistence. In selecting their food, they rely chiefly on smelling; and this sense does not deceive them. They easily distinguish between the noxious and the salutary, avoiding the one and feeding on the other. Some animals, such as wolves and ravens, discover their food at a distance, which, if we were to judge from our own sense of smelling, would appear altogether incredible. Others, as the eagle, the hawk, and the gull, have an amazingly acute eye; and, from a great height, perceive mice, birds, and other objects of prey.

As the different kinds of animals are admirably qualified for discovering their food, so they are well formed for gathering or seizing it. In graminivorous quadrupeds, there is a remarkable correspondence between the length of the legs and that of the neck. We do not find a very short neck in connection with long legs. The ox, the horse, and the sheep, are examples of the proportions of those different parts of the body. In some of the deer kind, indeed, the neck does not bear the same proportion to the legs as in the animals now mentioned; but they obtain their food chiefly by browsing on the branches of trees, in which case there is no need for a length of neck corresponding to the legs. They can easily pasture on an ascent; and Vaillant assures us that even the giraffe, the most remarkable of this tribe, is able to drink from a stream, the surface of which is lower than the ground on which he stands. The short neck of the elephant is remarkably compensated by the strong and flexible proboscis. [Pl. XVI. fig. 2, 3, 4, 5.]

The hooked beak of the parrot, necessary for climbing for food or for protection, is singularly inconvenient, apparently, for readily taking its food. The compensation is remarkable. The upper mandible is joined to the bone of the head by a strong membrane placed on each side of it, and not forming one piece with the skull, as is common with other birds. By this contrivance there is considerable motion allowed to the upper mandible, and food is more easily received into the beak. [Pl. XVI. fig. 7.]

The hook in the wing of a bat is also a beautiful instance of a compensating contrivance. [Pl. XVI. fig. 6.]

Monkeys are destined to live on trees; and their four prehensile members enable them to climb with the greatest facility. The tail of several kinds is a further assistance in this way of life. The natural food of swine is chiefly the roots of plants; and they have a snout fitted for digging up the earth. The goat is formed for ascending rocky precipices, to crop the leaves of those herbs and plants on which he delights. The squirrel feeds on the leaves and fruit of trees; and he is provided with feet which fit him for climbing. Woodpeckers have strong, wedge-like bills, for piercing the bark of trees; and they are provided with a long, slender tongue, armed with a sharp, bony point, barbed on each side, which, by means of a curious apparatus of muscles, they can dart out to a great length into the chinks of the bark, or into the holes which they have formed with their bills, in order to transfix and draw out the insects lurking there. Their legs and feet are admirably formed for climbing, and even the tail is made to coöperate for the same purpose. [Pl. XVIII. fig. 1, 2, 3.]

The tongue of the chameleon displays a very curious mechanism. It is contained in a sheath at the lower part of the mouth, and has its extremity covered with a glutinous secretion. It admits of being projected to the length of six inches from the mouth, with wonderful celerity and precision; and the viscous secretion on its extremity entangles the flies, and other similar insects, which constitute the food of the chameleon. [Pl. XIX. fig. 1.] Water-fowls feed upon fish, insects, and eggs of fish; and their bills, legs, wings, and whole structure, are fitted to their manner of life.* The size and strength of the wings correspond with the circumstances of the different kinds of fowls. Birds of prey, which must often seek their food at a distance, have large and strong wings; but in domestic birds, which can find

* The bill of the common duck is too remarkably fitted for procuring its food, to be passed over in silence. The upper mandible is furnished with large nerves, which extend to the extremity of the bill. By this means it readily distinguishes its favorite food in the mud, where it is fond of seeking it, and by which, also, the gratification of eating is increased. [Pl. XIV. fig. 1.]

"There is a remarkable contrivance of this kind in the genus *balæna*, or proper whale. Numerous parallel plates of the substance called whalebone cover the palatine surface of the upper jaw, and descend vertically into the mouth: the lower edges are fringed by long fibres, which serve the animal, when taking in the water, to retain the molluscæ with which the water abounds, and which constitute its food."—*Paxton.*

The middle claw of the heron and cormorant is serrated, the more easily to hold their slippery prey. The soland goose also has its bill serrated for the same purpose. [Pl. XX. fig. 1, 2.] Ed.

nourishment almost every where, the wings are short and small.

Were we to run over the organs of all animals for procuring their food and seizing their prey, from the trunk of the elephant to the proboscis of the bee and butterfly [Pl. XV. fig 6, & 8.], we should every where meet with the most astonishing adaptations and displays of the most consummate mechanical skill. We see a vast variety of food provided; a corresponding variety of tastes for enjoying it; and all animals furnished in one way or other with organs for taking possession of it. And is this vast, various, and complicated system the work of chance? Is not design,——are not wisdom and goodness obvious in the provision made for the sustenance of the different kinds of animals, in correspondence to their different tastes and appetites? The food does not form the taste; but the taste directs to the use of the food. Some animals could not live on that which is grateful to the palate of others; and although the animal, in a number of instances, might support a lingering existence on the food which it does not choose, yet, in these cases, it would neither attain the vigor of its nature, nor the usual term of its life. According to all our conceptions, nothing but a designing Being could have furnished provisions suitable to the nature of every animal, and formed each animal with fit organs for gathering that provision.

V. In many instances we find surprising adaptations of animals to peculiar circumstances. Under this head, I shall confine my observations to the camel and the rein-deer; the one a native of the arid plains in the warm and temperate regions of Asia and Africa; the other an inhabitant of high latitudes. The camel is found in warm climates, and on parched and sandy plains; and the structure of his body, and his habits, are accommodated to the circumstances in which he is placed. In the regions which he inhabits, the earth is seldom refreshed with showers; and, in many cases, only a few stunted shrubs or herbs appear in the midst of the sandy wilderness, or around the wells which are thinly scattered in the desert. In this situation, his place could not be supplied to man by any other animal. "The sand," says Denon,*

* A celebrated traveller and engraver. He accompanied Napoleon in his campaigns into Italy and Egypt; and has given descriptions and representations of scenery, and events connected with his travels, which gained him a high reputation. He died at Paris, April 28, 1825, aged 78.

"is truly his element; for as soon as he quits it and touches the mud, he can hardly keep upon his feet, and his constant trips alarm the rider for his own safety and that of his baggage." His rough and spongy soles are excellently fitted for traversing the ocean of sand: they do not crack with the heat.

Besides the four stomachs common to ruminating animals, the camel is furnished with a fifth, which serves as a reservoir for containing water. [Pl. XXI.] It is peculiar to this animal, and is so capacious that, according to Bruce,* it can contain water sufficient to serve him for thirty days. Russell,† in his Natural History of Aleppo, mentions a Bassora caravan, in which the camels remained fifteen days without water; but he adds, that the Aleppo and Bassora caravans are seldom more than three or four days without finding wells; although, at times, when obliged to leave the common track, the camels suffer an abstinence of six or seven days. The fifth stomach preserves the water in a state of perfect purity and limpidity, without permitting any part of the aliment, or of the fluids of the body, to mix with it. In traversing the vast burning deserts, which without his aid no human power could pass, when the camel is pressed with thirst, or has occasion for water to macerate his dry food in ruminating, he makes part of the water mount into his paunch, or even as high as the œsophagus, by the contraction of certain muscles. His stomachs are possessed of a peculiar sensibility, by which each opens to receive the food proper to it. He scents a pool of water half a league off.

As the camel is fitted for marching through the arid wilderness, so he can pass over the most barren region. He can subsist and toil on a very small quantity of food, and that of the coarsest kind, such as wormwood, thistles, broom, thorny shrubs, and other similar fare. When even this rough aliment cannot be obtained, he can subsist on a few pounded dates, or some small paste-balls of bean or barley meal. With a single pound of such food in a day, he can travel, for weeks together, upwards of 30 miles a day, under a load of 750 or 800 pounds. As he is so surprisingly fitted for passing parched and burning deserts, in which,

* A famous traveller, descended from the ancient race of Scottish kings. He devoted many years in examining the antiquities, the manners, and institutions of the Abyssinians, a people then (1769) known to Europeans only by name. He died from an accidental fall, 1794, æt. 65.

† Physician to the English factory at Aleppo, and afterwards of St. Thomas' hospital, London. His History of Aleppo is a valuable work, and has been translated into several languages. He died, 1768.

without his aid, man must inevitably perish, he is by the Arabs emphatically styled *the ship of the desert.* He is the great medium of commerce in the regions which he inhabits; and without him the wilderness would be altogether impassable.

The Arabs subsist on the milk of the female, in the different forms of curds, cheese, and butter; and they often feed on its flesh. They make slippers or harness of its skin, and tents and clothing of its hair. When alive, this animal is the treasure and support of its master; and, even when dead, contributes to his accommodation and comfort. Here, then, we have an unsightly, but inoffensive and docile animal, of peculiar conformation and habits; and that conformation and those habits admirably adapted to the physical state of those countries where he is found. And will the atheist allege that the sands and heat of the wilderness formed the spongy hoof and the fifth stomach of the camel, and endued him with the singular patience of hunger and thirst; or that the spongy hoof and water-bag of the camel created the vast sandy plain, and planted the stunted thorn in the desert? No sober man will attach the least credit to such allegations; for here we see an adaptation plainly indicative of mind, and which could only originate from a wise and benevolent *First Cause.*

But, leaving the parched deserts between the Euphrates and the Gambia, let us turn our eye to the arctic regions of America, to the mountains of Lapland, or to the wilds of Siberia: there we meet with an animal almost as useful as the camel, and perceive a striking adaptation in the rein-deer. This animal is a treasure to the Laplander. In winter, it draws his sledge with great rapidity over the frozen lakes, rivers, and snow-clad mountains of his country. Two of them yoked in a carriage can travel a hundred miles a day. Besides serving the purposes of rapid transportation, they are far more extensively useful. Their milk yields cheese; their flesh, a wholesome and nutritious diet. Their skin furnishes clothing; the tendons, bow-strings and thread; and the bones and horns, glue and spoons.

Let the camel and the rein-deer change places. Carry the latter to the burning sands of Asia or Africa, and transport the former to the confines of the arctic circle. What happens? Both become miserable and useless creatures. There is no adaptation in the broad, spongy sole of the camel, and no occasion for his fifth stomach. Neither his constitution nor his clothing is suited to the climate. He becomes an unprofitable and unhappy creature: he lingers, pines, and dies. Does the rein-deer fare better by the change? No. He is unable to bear the heat of the sun and the drought of the desert. His dense coat of hair is an intolerable burden, and he soon falls a victim to an unsuitable climate. Now, how shall we account for the suitableness of the creature to the circumstances in which he is placed, but by the admission of a wise First Cause? Insensible must be the heart which is not filled with admiration at such adaptations, and callous those affections which do not glow with gratitude to the bountiful Author of Nature.

INSECTS.

The structure of insects might furnish materials for a large dissertation; but it is intended to make only a few general remarks on the subject. We admire and applaud the consummate skill of the artist who forms any piece of machinery on a minute scale; as a watch that can be set in a ring for the finger. How delicate and exact must be the adaptation of the parts, and how accurate the workmanship of the whole! Ought not a similar admiration to accompany us when we pass through that province of nature where animal organization is set before us in miniature? Insects are commonly overlooked, or regarded with an eye of careless indifference. But the mechanism of their bodies, and their instinctive propensities, plainly indicate a designing cause.

There is a prodigious variety of insects, differing in figure, color, and disposition of parts. But here, as in every other department of sentient nature, there is a close connection between the external form and the habits of the animal. All the tribes of insects proceed from parents like themselves. The doctrine of *spontaneous* or *equivocal* generation was famous among ancient philosophers; who, although they did not think of applying it to the larger animals, where its falsehood was obvious, thought it accounted for the appearance of insects. Some observers of nature, perceiving that swarms of insects appeared on different substances, such as putrid flesh, and the leaves of plants, rashly concluded that these diminutive animals were produced by the action of the sun on those substances. Men long rested satisfied with this vague notion, which at once flattered them with the belief that they knew the truth, and relieved them from the trouble of careful inquiry and observation. But the experiments of

Redi,* Malpighi,† and others, dissipated the illusion, and established the important truth, that every animal proceeds from a parent of its own kind.‡

The exquisite organization of insects has excited the admiration of the most distinguished anatomists. "After an attentive examination," says Swammerdam,§ "of the nature and anatomy of the smallest as well as of the largest animals, I cannot help allowing the least an equal, or, perhaps, a superior degree of dignity. If, while we dissect with care the largest animals, we are filled with admiration at the elegant disposition of their parts, to what a height is our astonishment raised when we discover all these parts arranged, in the least, in the same regular manner!" In every department of animated nature design is so obvious that it is not easy to determine where it is most conspicuously displayed.

Insects have organs of sense as well as the larger animals. We can form no conception of any animal with more senses than we ourselves enjoy; and we cannot assert that all insects possess as many senses as are found in man. But we may confidently affirm that the Creator has bestowed upon them as many as are necessary for their preservation, in their respective conditions. All insects enjoy the sense of feeling in common with other animals. In some of them, we can discover no organs of vision; but many of them have two eyes, and some of them have more. It may not be easy to point out the ears of these minute animals; but it is certain that many of them possess the sense of hearing, or something analogous to it. Many of them seem capable of discovering their food by smelling; and they appear to exercise taste in the selection of it. Our inability to discover the organs of any particular sense in insects, is no evidence that they are

* A celebrated naturalist of Florence. He was not only a learned man, but a liberal patron of learning. He died, 1697.

† A physician of Bologna; author of several curious and important discoveries in anatomy.

‡ The dragon-fly—to mention one out of a thousand remarkable instances—is an inhabitant of the air, and cannot exist in water; yet, in this element, which is alone adapted for her young, she drops her eggs.

Not less surprising is the parental instinct of the gadfly (*gasterophilus equi*), whose larvæ are destined to be nourished in the stomach and intestines of the horse! How shall the parent convey them there? By a mode truly extraordinary. Flying round the animal, she curiously poises her body while she deposits her eggs on the hairs of his skin. Whenever, therefore, the horse chances to lick the part of his body to which they are attached, they adhere to the tongue, and from thence pass into the stomach and intestines. And what increases our surprise is, that the fly places her eggs almost exclusively on the knee and the shoulder; on those parts the horse is sure to lick.—*Paxton.*

§ An eminent entomologist of Amsterdam. He studied and wrote several works of merit at Leyden. He died, 1680.

destitute of that sense. The organs may be so minute as altogether to elude our discernment. Besides, insects may enjoy something analogous to our senses, though not through the medium of organs constructed as ours are.

In insects (I use the word in a vague sense), respiration is carried on by means of *tracheæ*, or air-tubes, running below the skin, and communicating with the surface by numerous openings. In some of them, the air passes through the cuticle in every part of the body. Their organs for the reception of their aliment are very differently formed. Such of them as eat have claws for seizing their food, and teeth for gnawing and comminuting it. Those which subsist by sucking fluids are provided with a pump, longer or shorter, according to their necessities. Many kinds, which, at first sight, appear to have no opening for the reception of nourishment, are furnished with two large pincers on their head for the conveyance of their aliment. There is much variety in the internal organization of insects; but in all of them the great process of nutrition is successfully carried on.

Insects can provide for their safety in different ways. Some escape by flight. Some, for the purpose of concealment, make their abode in places of the same color with themselves. The skin of some is so hard as to form a kind of coat of mail; and some are provided with a formidable sting. No species perishes, either through its own helplessness, or the violence of its enemies. [Plates XV. and XXII.]*

CHAPTER V.

INSTINCT.

On glancing at animated nature, a grand characteristic of man presents itself to our view; his capacity of reasoning, deliberating, planning, and varying the means which he employs for the accomplishment of his ends according to the exigencies of the case. The inferior animals almost always use the same means for the attainment of the same ends. They are either altogether incapable of reasoning, or possess the faculty in a very low degree; and, accordingly, if we meet with any improvement among them, it is that of a few

* The number of species of insects known to entomologists, and preserved in cabinets, is, at present, not less than forty thousand. This number, however, must probably form a small proportion of the whole number which exist upon earth.—*Dr. Ware.*

individuals only, under the special instruction of man; not of the species, or of a society. But we see men in one age, or in one country, without knowledge, and without curiosity, roaming, singly or in little bands, in the desert; without foresight or steady industry; rudely feeding on the spontaneous fruits of the earth, or on the precarious supplies of fishing and hunting; and lodging in a cave, under the projection of a rock, in the shelter of a thicket, or under a tent of stakes covered with bushes, bark, or skins; the erection of which is scarcely the labor of an hour. Their clothing is as rude and scanty as their other accommodations.

At another period, or in a different country, we find them comfortably clad; surrounded with flocks and herds, and removing from place to place for the conveniency of pasture; occasionally soliciting the earth, by means of agriculture, to contribute more liberally to their subsistence and comfort; living in movable habitations, and enjoying unpolished plenty. If we still follow the stream of human improvement, after passing different stages and through various scenes, we come to a busy multitude pursuing, with ambitious industry, their several employments, under the protection of equal laws; building houses; clearing the forest; planting trees; applying all the powers of their labor and ingenuity to the cultivation of the soil; plunging into the bowels of the earth in quest of minerals; draining marshes and lakes, and straightening the water-course; making roads and bridges; digging canals and deepening rivers; engaged in manufactures and commerce; exchanging the productions of one quarter of the globe for the superfluities of another; building and embellishing magnificent cities; forming literary and scientific establishments; impressing air, fire, and water, into their service; constructing machines for the abridgment of labor; exploring the different corners of the earth, and making themselves acquainted with the inhabitants and the productions of every country; investigating the physical laws of the universe; ascertaining the motions and magnitudes of the heavenly bodies; calculating the distances of the sun and planets, measuring the velocity of light, and observing the aberration of the fixed stars.

Such is a sketch of the career of society from rudeness to civilization, agreeably to the different states in which mankind have been found.* The individual exhibits something of a similar progress in improvement. His first efforts are

* Nothing that has been here said is intended to apply to the original state of man; but merely to mark his progress from the lowest state of degradation in which he has been found to the highest degree of civilization.

awkward; his productions rude and clumsy. He improves by observation and practice, and gradually advances from one stage of excellence to another. The observation applies, not to his mechanical skill only, but to his moral and intellectual attainments also.

If we turn our eye to the inferior animals, a very different picture is presented to our view. Every species is stationary. With some minute modifications, depending on local circumstances, it is the same in every age and in every country. In cases, indeed, where the inferior animals are trained to the service of man, their natural disposition and habits are, by subjugation and discipline, occasionally, in some respects, altered and improved. Any progressive attainment, however, is merely that of the individual. Societies never advance. In most instances, the individual also is altogether stationary. The bird builds its nest, and the bee constructs its cell, as perfectly on the first attempt, and without either instruction or experience, as at any future period. This, I apprehend, is *instinct* in the strictest sense of the word. I do not pretend to draw a distinct line between reason and instinct, or in every instance to determine where the one ends and the other begins. But the general notion of instinct is, a propensity prior to experience, and independent on education. Some instincts, however, are capable of accommodation, or even of improvement. The creature is susceptible of some degree of education. But other instincts, particularly those of insects, are invariably the same.

In this chapter, I purpose to take notice of some of the instincts of the inferior animals relating to the preservation of the individual, and to the continuation of the species. In the last chapter, I made some observations on corporeal organization, and shall now attend to the corresponding instincts. These, at times, are so closely connected, and so run into each other, that it is not easy to treat of them altogether separately. As, in the last chapter, our attention was chiefly turned to organization, so, in the present, instinct will be our main subject.

I. The different kinds of animals instinctively make use of the means of defence and safety with which they are provided. The calf pushes with its head, even before its horns appear—a proof that the instinct exists prior to the expansion of the parts for the employment of which it is implanted. The horse uses both his teeth and his heels, or treads down his adversary with his fore feet; although in a wild state his heels are the main instrument of defence; and it may be added, that, in that state, when horses sleep, one remains awake to give warning of approaching danger. The dog, in combating the enemy, employs his teeth, and the feline tribe uses both teeth and claws. The insect has recourse to its sting. The ox never attempts to bite, nor the dog to butt with his head: each of them instinctively feels that he possesses more effectual means of defence. The hare has recourse to flight, and commonly betakes itself to high ground, as the length and muscularity of its posterior extremities give it an advantage in ascending the hill. By its doublings, it often perplexes and eludes the enemy. The cunning of the fox, in providing his food and in making his escape from his pursuers, is proverbial.

The inferior animals instinctively know their enemies, and apprise each other of their common danger. The fox devours birds; and birds no sooner see him approach than they utter cries, which are understood by the whole flock, and put them instantly upon their guard. Every dam has a call for her young, and in every flock and herd there are expressions which bring numbers together; expressions of enjoyment or suffering, of desire or aversion. By a particular sound, the hen invites her chicks to partake of food; and they instantly comply with. the invitation. By a different cry she apprises them of danger on the approach of the hawk, and, although they have never heard the cry before, they hasten to her for concealment and shelter.

When marmots are gamboling among the grass, they station one of their number as sentinel upon a rock. If the sentinel perceive a man, an eagle, a dog, or any other enemy, by a whistle, he gives his companions notice of their danger, and he is the last to enter the hole leading to their habitation. Monkeys, and several other animals, employ similar precautions. In many instances, animals of the same kind combine their efforts in order to repel a common enemy. A single rook is no match for a kite; but whenever the kite appears, the rooks that are within sight join in attacking him. The migration of birds discovers a wonderful instinct, and may be considered as a means of security. Several kinds of them, at stated seasons, quit their summer abodes, and, in great flocks, repair to the places where the temperature is most suited to their constitutions, or where their food is most abundant.

Many animals instinctively employ proper means for healing their wounds and curing their diseases. The Kamtschadales confess that they owe to the bears all their skill both in physic and surgery; that, by observing the herbs with which those animals rub their wounds, and to which they have recourse when sick or languid, they have become acquainted with most of the simples in use among them, either in the way of internal medicine, or of external application. In short, as all animals possess some means of defence and safety, so they have corresponding instincts which prompt them to the due application of those means.

II. As the inferior animals are provided with instruments for procuring their food, so they are endued with an instinctive skill in the use of those instruments. Every animal instinctively knows the food that will nourish it. The chick, almost as soon as it escapes from the shell, runs to its food, and pecks with its bill. The principal food of the rein-deer, in winter, is a kind of white moss; and the animal digs with its feet under the snow in order to obtain it. Sheep act in a similar manner. The beaver lays up a stock of winter provision: the squirrel does the same. Numbers of the crow kind hide food in holes, when they have it in plenty, and apply to their concealed stores in times of scarcity. When ravens find themselves unable to break the shells of muscles, and other *testacea*, they carry them to a great height in the air, and accomplish their purpose by letting them fall upon a rock. In some parts of the country, furze is occasionally, in seasons of scarcity, thrashed as food for horses; but the horse can perform the operation for himself. He tramples upon the branches, and paws them with his fore feet, till the prickles are mashed together or rubbed off; and so completely does he perform the work, that the food thus prepared might be squeezed by the hand with impunity.

Gass* informs us, that, in the country towards the source of the Missouri, wolves, in packs, hunt the antelope, which is too swift to be run down by a single wolf. The wolves take their station; part of the pack begins the chase, and, running in a circle, they at intervals relieve each other. From Le Page de Pratz,† in his History of Louisiana, we learn that wolves discover a similar sagacity in hunting the buffalo. The arctic gull, which is somewhat larger than the common gull, often pursues it. The gull, after flying for some time, with loud screams and evident marks of terror, drops its dung, which its pursuer immediately darts at, and catches before it falls into the sea. In insects that undergo

* Author of a Journal of the Voyages and Travels of a Corps of Discovery under the Command of Captains Lewis and Clarke, in the years 1804—1806. Mr. Gass was one of this exploring party.

† Author of a History of Louisiana, 2 vols., translated from the French. (London, 1763.)

several transformations, the instinctive propensity changes with the appearance of the animal. Some that in one stage feed on putrid bodies, in another extract a delicious aliment from herbs and flowers. This instinctive sagacity appears throughout all animated nature.

III. Many animals live without any fixed habitation, and the dwelling which others frequent is of the simplest kind; as the form of the hare's. Some animals have no particular place of residence during winter, as many kinds of birds, but prepare a place in spring for bringing forth and rearing their young. Others, as the beaver, have no fixed residence in summer, but provide a comfortable habitation against the severity of winter. In the construction of their houses many animals display much sagacity; and as an example of this we may select the beaver. He is a native chiefly of high latitudes, and, though not possessed of all that surprising sagacity and ingenuity which some distinguished naturalists have ascribed to him, is endued with wonderful instincts.

The beavers, when numerous, construct their houses on the margin of ponds, lakes and rivers. They always choose a place where the water is so deep as not to freeze to the bottom. When they build on small rivers, where the water is liable to be drained off by a failure in the sources which supply the stream, they provide against the evil by making a dam quite across the river at a convenient distance from their houses. This shows the foresight and sagacity of an engineer in erecting a fort, or marking out the ground for the site of a city. The shape of the dam varies according to circumstances. If the current of the river be slow, the dam runs almost straight across; but if the current be rapid, the dam is formed with a considerable curve towards the stream, so that the different parts of it support each other, like an arch. The materials employed are drift wood, green willows, birch and poplars, if they can be gotten; also mud and stones, intermixed in such a manner as contributes much to the strength of the dam, which, when the beavers are allowed long to frequent a place undisturbed, by frequent repairs, becomes very firm.

The beavers always cut their wood higher up the river than their houses, so that they enjoy the advantage of the stream in conveying it to the place of its destination. On the margin of lakes, where they have always a sufficient depth of water, they construct no dams. Their houses, however, are built of the same materials as the dams; and their dimensions are suited to the number of inhabitants, which seldom exceeds four old and six or eight young ones. The great aim of the beaver is, to have a dry bed; and their houses, which are but rude structures, have only one door, always opening to the water.* The otter, likewise, discovers much sagacity in forming his habitation. He burrows under ground, on the banks of rivers and lakes. He always makes the entrance to his house under water, working upwards towards the surface of the earth, and forming different chambers in his ascent, that, in case of high floods, he may still have a dry retreat. He forms a small air-hole reaching to the surface; and, for the purpose of concealment, this air-hole commonly opens in a bush.

The marmot, also, displays a surprising instinct in preparing his habitation. In the declivity of a hill he digs two small subterraneous passages, opening at some distance from each other. They gradually ascend, and approach each other, till they meet in a common trunk. In this common trunk, the marmots form a level dwelling, and carpet it carefully with moss and hay. One of the passages forms an entrance to the house; in the other the excrements are deposited. A number of marmots lodge in the same house, which is formed by their united labor. On feeling the approach of winter, they closely shut up the passages to their house, and sleep till the return of spring. In the marmot, Spallanzani† found living action to cease in a temperature about 29° or 30° Fahrenheit.

IV. In this section we shall take notice of instincts relating to the continuation of the species.

Throughout the wide extent of animated nature, so far as it falls under our observation, individuals die, but the species continues. The Author of that constitution of things, which carries into execution the first of these, has made an adequate provision for the last. The reproductive powers of the different kinds of animals are admirably adjusted to their natural term of life, and to the dangers to which they are exposed; so that no species ever perishes. Even where the life of the individual does not extend beyond the short space of a day, there is as sure a provision made for the continuation of the species, as where the life of the individual extends to a hun-

* See Hearne's Journey to the Coppermine River. Hearne was an English traveller in the service of the Hudson's Bay Company. He was employed, in 1769, to explore the north-western part of the American continent. He died in 1792. The narrative of his researches is entitled "A Journey from the Prince of Wales's Fort, in Hudson's Bay, to the Northern Ocean (1795; 4to.)

† Professor of natural history at Pavia, and author of many valuable works. He died, 1779.

dred years. The kinds which are liable to great peril and waste are very prolific, and the fecundity of those which are less exposed to danger is confined within narrower limits. Hares and rabbits bring forth far more young than lions and tigers; wrens are much more prolific than eagles; and the fecundity of cod-fish and salmon greatly exceeds that of the whale.

The earth exhibits some wonderful organic remains. The bones of those animals to which the names *mammoth*, *megatherion*, &c. have been assigned, indicate skeletons unlike to those of any living creature presently known; and we pretend not fully to account for the remains described by Cuvier and others. Some of them, at least, seemed to have belonged to the globe, under a constitution anterior to the present. But although we cannot satisfactorily explain these phenomena, yet we are acquainted with no clear evidence of the destruction of any species of animals that ever belonged to the earth under its present forms.

For the production and rearing of their young, there is, in every kind of animals, a most astonishing combination of organization and instinct. Neither of these is sufficient by itself. The organization without the instinct would be unproductive, and the instinct without the organization would be of no avail; but united they fully accomplish the end. We are satisfied that nothing like legitimate evidence can be adduced to prove that the organization is the cause of the instinct. They are wonderfully conjoined; but we believe they are independent on each other, as much as the candle and the candlestick, the ink and the inkstand. Is not, then, the combination of two such independent circumstances, for an important purpose, a decisive evidence of intelligence and design? If it be urged that the organization is the cause of the instinct, we wish to know who formed this constitution of things. Who formed the organization which is accompanied with such instincts? It was not chance, surely, but an intelligent and wise cause.

We shall make a few more remarks on the instincts relating to the continuation of the species, under the heads of the nidification and incubation of birds, providing food for the young, and defending them.

1. Among the feathered tribes, pairing is very common. In winter, indeed, birds in general are without any fixed habitation; and many kinds of them appear in large flocks, without any particular attention of one individual to another. On the return of spring, however, the scene changes. The gen-

eral society is dissolved, and many partnerships, consisting each of a male and female, are formed. The pair fix on a suitable spot, and by their joint labor construct a habitation.

2. Most birds prepare their nests with much care; and many of them discover ingenuity in the design, and neatness in the execution. But the ingenuity and the neatness belong to the species, and in no degree characterize individuals. They have no need of an apprenticeship. The nest of those birds which have paired for the first time is not more rude or inconvenient than that of those which have repeated the labor of nidification for a number of years. There is no deficiency in the first from want of instruction and practice, and the last have gained nothing by observation and experience.

> The dove that perched upon the Tree of Life,
> And made her bed among its thickest leaves,
> All the winged habitants of Paradise,
> Whose songs once mingled with the songs of Angels,
> Wove their first nests as curiously and well
> As the wood-minstrels in our evil day.

The crow and the magpie, the lark and the linnet, and every other kind, has each a peculiar manner of building its nest; and every individual of the same species, in similar circumstances, follows the same model, and uses similar materials. The instinctive propensity seems, in various instances, to accommodate itself to peculiar circumstances, both in building the nest, and in the process of incubation. In countries infested by monkeys, some birds, which in other climates build in bushes or in the clefts of trees, suspend their nests upon a slender twig, and so elude the mischievous propensities of the monkey. With us, ravens build on trees; but in the cold climates of Iceland and Greenland, they construct their nests in the holes of rocks.

The nest is always suited to the size of the bird, and to the number of its eggs and young. Many small birds display much sagacity in concealing their nests by tufts of grass, or by twigs and leaves. In the nest we see a receptacle provided for eggs before they come to maturity, even before the bird knows that it is to lay them. Each species lays a determinate number; and it appears that, in this process, some birds, at least, do not act under the influence of physical necessity, but have, to a certain extent, an instinctive volition. The soland goose, if undisturbed, lays only one egg; but if that be taken away, she lays a second; if the second be removed, she lays a third; but no more for the season. In a number of instances, if one egg be daily abstracted from the nest, the bird continues laying till she obtain her complement. In this way a swallow has been made to lay nineteen eggs in one season.

In general, the smallest kinds of birds are most prolific; but from this general rule there are some exceptions. The eagle lays one, sometimes two eggs; the crow, four or five; the titmouse, seven or eight; the small European wren, fifteen; the humming-bird, however, a very little creature, lays only two; and yet the humming-birds are more numerous in America than the wrens in Europe, being protected by the smallness of their size, the rapidity of their flight, and their daring courage. After the complement of eggs is provided, a new and interesting scene is exhibited. All the former habits of the bird seem at once to forsake it. The animal that before was almost in perpetual motion, hopping from twig to twig, flitting from tree to tree, rising into the air, flying to considerable distances, chirping and singing, becomes at once motionless and mute. She takes possession of her nest, and with assiduity broods on her eggs. In some instances, as in rooks and in crows, the male supplies her with food; and in others, as in pigeons, relieves her by filling her place. In this way, the small eggs, which otherwise would soon lose their heat, are always kept at the due temperature. We may add that the albumen, or white of the egg, is a feeble conductor of caloric, and consequently tends to preserve, during the occasional absence of the parent bird, that equable temperature which is so necessary to the evolution of the ovular embryo.

The eggs of the larger birds, on account of their greater size, retain heat longer than those of the smaller birds: accordingly, the larger birds occasionally leave their nests for some time, without injury to the process of incubation. Some of them, however, when they go to feed, cover their eggs; the eider-duck does it with down taken from her own breast. But small birds sit most assiduously, otherwise their eggs could not be hatched. Here we find an amazing adaptation of instinct to the circumstances of the animal, for which we see no rational way of accounting, without ultimately resorting to a wise first cause. The bird does not understand the process which it is carrying on: it does not know the end to be accomplished; yet it carries on the process with the most minute precision, in opposition to all its habits during the other seasons of the year; and in the absence of disastrous accidents, arising from foreign causes, it accomplishes the end with infallible certainty.

Fish, with a few exceptions, are oviparous; and generally, after depositing their eggs, pay no further attention to their progeny. There are, however, some striking exceptions. The female cayman repairs to the banks of a river; forms a large hole in the sand, and there deposits her eggs. She covers them carefully, and rolls herself on the place to smooth it, that it may not be discovered. She leaves her eggs to be hatched in the sand; but her instinctive propensity prompts her to return, at the exact time, to uncover them and break the shells, when the young caymans come forth.

3. The instinctive propensities of animals do not terminate with the appearance of their progeny in the world, but continue as long as the aid of the parent is needful for rearing the offspring. Most animals have a strong affection for their young, which manifests itself in providing food for them. And in order to the supply of this food, there is, in many instances, a wonderful physical constitution in the parent, as well as surprising instincts in the progeny. Thus, in the human race, such is the constitution of the mother, that she secretes a nutritious fluid for the support of her child, and the secretion of this fluid accompanies the need for it. It does not depend on volition. It does not exist at any other time. And in the child what a wonderful instinct displays itself in the complicated muscular action by which this fluid is obtained! Sucking is an operation in which the infant soon becomes expert; but few grown persons can perform it. The instinctive skill is lost when the need for it ceases.

In many quadrupeds, as well as in the human race, the mother secretes a nutritious fluid for the support of her offspring, and she can yield nourishment to her young while she herself is feeding. There is a remarkable correspondence between the instinct of the young animal and the provision made for its support. Almost as soon as it comes into the world, it seeks to avail itself of the provision already prepared for its sustenance. Now, how happens it that this fluid is secreted just at the time when it is needed? Who established that constitution of the animal by which the secretion takes place? How shall we account for the young animal, almost at the moment of its birth, groping for the organ from which it is to receive food, and employing the means necessary for obtaining that food?

Human infancy is long, and we find a corresponding affection and solicitude on the part of the parents. If a child be delicate and sickly, the parents feel for it a more tender affection, and exercise towards it a more assiduous attention, than towards the infant of a more robust constitution. The watchful care accommodates itself to the exigency of the case, and generates a degree of affection, without which the anxiety and toil would be altogether insupportable. We may trace this process in the human mind for a little way, but it ultimately terminates in the instinctive principles of our nature. Young persons are capable of receiving instruction as well as food from their parents, and accordingly in the human race parental affection is permanent. After it has ceased to display itself in nourishing and defending, it appears in instructing and directing.

Birds do not secrete a fluid for the nourishment of their young; but they are diligent in providing food for them, which is earnestly solicited and greedily received. We may here remark, that it is the albumen chiefly which is expended in the formation of the chick; the yolk of the egg, without undergoing any considerable change, being wrapped up in its intestines to nourish it, till it receives or is capable of gathering other food. In most instances young birds would inevitably perish without the nursing care of the parents. In some cases, however, the young can provide for themselves almost as soon as they escape from the shell; and in these instances the fostering instinct of the parent soon disappears. Some insects display an astonishing instinct in providing food for their young before they are hatched.* Others, which make no such provision, lay their eggs in places where the young, when they appear, can easily find subsistence. These instincts must proceed either from the animals themselves, or from some Being possessed of reason and intelligence; but they cannot originate with the inferior animal itself, for it is obviously destitute of reason, and incapable of that foresight and wisdom which its cares and precautions indicate. In order to account for these instincts, we must ascend to a wise and benevolent Intelligence.

4. All animals defend their young; and, in obeying this instinctive impulse, the mother seems, in many instances, to lose her natural habits, and to assume a new character. The domestic hen, a stupid and timorous bird, becomes fierce and violent in defending her chickens. Even the harmless and inoffensive ewe assumes a menacing air, stamps with her foot, and seems to bid defiance to those who approach her lamb. But as the lamb acquires strength, and is able to run with its mother, her assumed character forsakes her, and she

* See Smellie's Philosophy of Natural History, Dr. Ware's ed. p. 115

has recourse to flight. Hinds anxiously conceal their fawns, and, in order to draw the dogs away from them, present themselves to be chased. It is at once amusing and affecting to observe the artifices employed by the lapwing to decoy the intruder to a distance from her young.

The Kamtschadales never venture to fire upon a young bear when the mother is near; for if the cub falls, she becomes enraged to a degree little short of madness, and if she gets sight of the enemy, will only quit her revenge with her life. The same instinct is remarkably apparent in some inhabitants of the waters. The morse and the polar white bear have a great affection for their cubs, and are courageous and active in defending them.* The sea otter pines to death at the loss of its young, and breathes its last on the spot where they have been taken from it. Throughout every province of animated nature, we meet with wonderful instincts, all directed to the preservation of the individual, and to the continuation of the species. Every instinct appears exactly in its proper place. Were the instincts to be altered, or those belonging to one species transferred to another, the harmony of the system would be deranged, and disorder ensue. For instance, were the sheep, its time of gestation continuing the same as at present, to come in season at the same time with the mare, it would bring forth at a period when the inclemency of the weather would destroy both the mother and her young.

If instincts result, as some have imagined, from conformation of parts, who organized the animal? If they flow from mechanical impulse, who constructed the machine? Where is the moving power? To talk of *attraction*, *gravitation*, *nature*, *appetency*, &c., in order to account for the existence or

* Speaking of the *morse*, Captain King (author of the 3d volume of Cook's Voyages to the Pacific, in 1776—1780) says,—"On the approach of the boats towards the ice, they took their young ones under their fins, and attempted to escape with them into the sea. Some, whose cubs were killed, and left floating on the surface of the water, rose again and carried them down, sometimes just as our men were on the point of taking them into the boat, and could be traced bearing them to a considerable distance through the water, which was stained with their blood. They were afterwards observed bringing them at intervals above the surface, as if for air, and again plunging under it with a horrid bellowing. The female, in particular, whose young one had been killed and taken into the boat, became so furious, that she struck her two tusks through the bottom of the cutter."

The affection between the polar bear and her cub is so great, that they will die rather than desert each other. "We saw two white bears in the water, to which we immediately gave chase in the jolly-boat, and killed them both. The larger, which probably was the dam of the younger, being shot first, the other would not quit, but remained swimming about, till, after being fired upon several times, it was shot dead."—See *Cook's Third Voyage*.

characteristic propensities of living creatures, is merely darkening counsel by a multitude of words. It is a vain attempt to substitute sound for sense; for where is there any rational way of accounting for the various instincts of animals, but by referring them to a powerful, wise, and good Intelligence? In the instincts of the creature we see the perfections of the Creator; and may apply to instincts in general what Dr. Reid says of bees in the construction of their cells. "They work most geometrically, without any knowledge of geometry; somewhat like a child, who, by turning the hand of an organ, makes good music, without any knowledge of music. The art is not in the child, but in him who makes the organ. In like manner, when a bee makes its combs so geometrically, the geometry is not in the bee, but in that great Geometrician who made the bee, and made all things in number, weight, and measure." If we do not see other animals displaying the geometry of the bee, we observe them, in a similar manner, employing suitable and effectual means for the accomplishment of their ends.

Thus, in our cursory glance at animated nature, we have seen great uniformity accompanied by surprising variety. The same general outline, with various modifications, prevails widely in the formation of living creatures. If we examine any one animal, we find its parts admirably adapted to each other. They form a harmonious whole. By means of bodily conformation and instinctive propensity, an adequate provision is made for the preservation of the individual, and the continuation of the species. Every thing goes on in a regular and uniform course. We never see any new species of animals appearing, nor any old kinds ceasing to exist. We meet with no metamorphoses of animals into a species different from that of their parents. By adventitious circumstances, the size, strength, and, in some measure, the instincts of animals, may be altered; but still the character of the species remains essentially the same.

There is an amazing gradation of animated beings, but even the classes that seem most nearly allied are distinct. Each kind continues what it originally was. We never see one species either suddenly, or gradually in a long succession of ages, transformed into another. No species either rises or falls in the scale. Men, and all other animals, continue such as they have been from the earliest records of time. The different species approach each other; but still they are separated by an impassable barrier. Animated nature thus exhibits undeniable marks of design, and consequently leads us, with irresistible force, to a powerful, wise, and good Being, who created, and continues to superintend, the system.

We now proceed to *inanimated nature;* and I apprehend we will find it wisely constituted, and bearing a gracious relation to living creatures. As nothing within the sphere of our knowledge gives us any reason whatever to believe that the one of these formed the other, we must attribute both to the power, wisdom, and goodness, of a Supreme Intelligence.

CHAPTER VI.

THE OCEAN.

THE terraqueous globe is an oblate spheroid, having its equatorial diameter somewhat longer than the polar. The globular figure is the fittest for the steady motion of the earth in its orbit, and for its diurnal rotation on its axis: it is also the most capacious. The earth is so firmly compacted, that although it moves in its orbit with the prodigious velocity of a thousand miles in a minute, yet no part of it is dissipated or shattered. It is a globe of great solidity. Some, indeed, have supposed that there are vast caverns in its bowels; but the experiments of Dr. Maskelyne* and Professor Playfair,† on the mountain Schehallan, seem to disprove the supposition; as they show the earth to be more dense than that mountain, and nearly five times more dense than water.

On a general survey of the earth, the first thing that strikes us is its division into sea and dry land, the ocean occupying more than two thirds of the surface of the terraqueous globe. For the ocean there is no physical necessity. The globe might have existed without it, and probably some of the orbs of the solar system are not provided with a proportion of water equal to that which obtains on the earth which we inhabit. We may suppose earth and water to exist together

* An eminent mathematician and astronomer of London. He went, in 1761, to St. Helena, in order to observe the transit of Venus. In 1774, he was employed at Greenwich in making observations on the eclipses of Jupiter's satellites. The same year he went to Scotland to ascertain the gravitative attraction of the mountain Schehallan, in Perthshire. He died in 1811.

† Professor of mathematics at Edinburgh. The latter part of his life he devoted to the study of geology. The experiment mentioned in the text was made in 1816. He died 1819.

without design. But if it shall appear that the ocean is a great component part of one whole, that it is not only admirably constituted in itself, but that it is essential to an established system, then we are entitled to adduce it as an evidence of design. If it be well fitted for accomplishing the purposes which it serves in the system, it is a proof of wisdom: if these purposes be beneficial, if they contribute to the existence and happiness of sentient beings, we contend that it is a display of goodness.

Let us glance,

I. At the ocean considered in itself;

II. At the purposes which it serves in the system of our world.

Under the first of these heads, we shall take notice of its saline qualities, its tides, and its inhabitants.

I.—1. In attending to the ocean, we are struck with the saltness of its waters. This is one grand means of resisting putrefaction, and of preserving the great fluid mass in a wholesome state; for if the sea were not impregnated with saline bodies, the putrefaction of the great mass of animal and of vegetable matter which it contains would soon prove fatal to the inhabitants of the earth.

Fresh and stagnant waters soon putrefy. But in the waters of the ocean, stagnation and putrefaction are equally unknown. According to some, the ocean is salter in tropical climates than in higher latitudes. But the observations and experiments of De Pages present a different result. The fact, however, is certain, that the water of the ocean is as free from putrefaction at the equator as toward the pole. And we may observe, that if within the tropics, where the temperature is highest, and the tendency to putrefaction greatest, the water is not more salt, it there feels most sensibly the current of rotation, or the general motion of the water from east to west, particularly observable within the torrid zone. The saltness of the ocean is every where proportioned to the need for it, in order to the preservation of the water in a salubrious state.*

To me it seems evident that the saline qualities of the

* If the mean saltness of the sea were much greater under the equator than in the temperate zone, a current at the bottom, from the equator towards the pole, would be the result. The mean density of the water of the sea, on an average, is

From 0° to 14° lat. .... 1.0272.
From 15° to 25° .... 1.0282.
From 30° to 44° .... 1.0278.
From 54° to 60° .... 1.0271.

HUMBOLDT, *Pers. Nar.* i. 64.

ocean are a proof not of design only, but of wisdom and goodness also; for here we see means adapted to an end: these means answer the end; and the end itself is beneficial. I see no physical necessity for the saltness of the ocean. The water, at first fresh and stagnant, might have become one great putrid mass, destroying sentient beings in the deep, and diffusing pestilential and deadly vapors over the dry land. In order, then, to account for the saline impregnation of the ocean, we must have recourse to a designing cause.

Some have endeavored to account for the saltness of the sea, by supposing that saline particles are washed down from the earth by the rivers, and that the ocean has derived its saltness from the accumulation of these particles. This hypothesis does not militate, in any degree, against the existence of a wise designing cause; for still we see adequate means employed for the accomplishment of a beneficial end, and whatever these means are, the argument in proof of design is the same. But to me the hypothesis seems pressed with insuperable difficulties. Were it true, we must either suppose the saltness of the sea to be increasing, or the saline particles of the earth to be exhausted. There is no proof, however, that either of these is the case. The last, indeed, is altogether out of the question; and as to the saltness of the sea, I believe it was the same five thousand years ago as at this day.

According to Davy,* almost all solids and fluids, even the purest distilled water, contain saline matter.† But I know of no proof that the accumulation of this matter in the ocean is derived from the rivers. If it were so, would not the sea be more salt towards the mouths of great rivers than at a distance from them? This is not the case. Lakes which have an outlet are found to contain fresh water: those that have no outlet are generally salt. But if the sea derived its saltness from the rivers, then those lakes that are fed by rivers should discover the saline quality in their waters, even though they have an outlet; for I know of no principle by the operation of which the saline matter can be entirely car-

* An eminent chemist, who, from obscure origin, and unaided by friends, raised himself to such distinction that he was chosen, at the age of 22, to fill the chair of chemistry, at the Royal Institution of London. His testimony on the subject of religion is too valuable to be omitted here. "I envy," says he, "no quality of the mind or intellect in others; not genius, power, wit, or fancy. But if I could choose what would be most delightful, and I believe most useful to me, I should prefer a firm religious belief to every other blessing."

† There are no saline qualities in water when first distilled. The salts mentioned by Sir H. Davy are subsequently absorbed from the atmosphere.—Ed.

ried off through the outlet. The water of Lake Ontario is as sweet as that of Lakes Superior or Michigan ; and the intervening lakes, Huron and Erie, discover no more saltness than those from which they draw their supplies. We may add that the De la Plata, Mississippi, and Nile, are as sweet when they meet with the waters of the ocean as at their source. Lakes without an outlet, or inland seas where the surface of water is too small to feel, in any considerable degree, the attraction of the sun and moon, are very salt ; and, from the conformation of the adjacent lands, they are commonly much agitated by winds.

The Dead Sea, or Lake Asphaltites, has been long famous on account of its saline impregnation ; and although many fables have been related concerning it by Josephus and others, it is true that its waters are of uncommon density. It contains upwards of forty per cent. of saline matter, chiefly muriate of magnesia and of lime. The Caspian Sea is, at least, as salt as the ocean, except where it is sweetened by the waters of the Volga, which is about the distance of ten leagues from the influx of that river. It is also much agitated by winds. The Black Sea is less salt than the ocean ; but several great rivers pour their waters into it, and a constant current sets through the Straits of Constantinople towards the Propontis. The Lake Aral is very salt. Thus, in small seas, there is a compensation, in one way or another, for the want of tides. Now, if the quantity of saline impregnation is, in every instance, proportioned to the circumstances of the case, is not this an evidence of design ?

2. The tides keep the water of the ocean in perpetual motion, and contribute to the preservation of its salubrity. They also afford a hint to man when investigating the laws of nature : they are an instance of the great law or fact of gravitation, which so widely pervades the universe. They depend chiefly on the ratio in which gravity acts, and form one instance of the wisdom and goodness manifested in that ratio. Tides are owing principally to the action of the moon. If that planet were quiescent, we would have high water twice every 24 hours. But the moon is continually in motion round the earth, and advances so far every 12 hours, as to make it about 25 minutes ere any meridian of the earth, after it has performed half a revolution, come under her centre ; and consequently about 12 hours and 25 minutes intervene between the high water of two successive tides.

Into the theory and phenomena of the tides, it is not the object of the present treatise to enter Suffice it, therefore, to say, that the tides contribute to the accomplishment of a beneficial purpose; for, by the saltness of the water, and the action of the tides, the ocean is preserved from stagnation and putrefaction. Here we see one purpose of a secondary planet attending a globe constituted as ours is. There are no tides, it may be alleged, in the Mediterranean and Baltic; and yet these seas, although not uncommonly salt, are as free from putrefaction as any of the waters of the ocean. In the Mediterranean, however, there is a tide, though small and irregular. But there is generally a current passing through the Straits of Gibraltar into the Mediterranean; it sometimes sets out, when the ebb tide in the Atlantic is great. In the Baltic, the water is not so salt as in the ocean. Its saltness is increased by a westerly gale, and the waters raised somewhat like a tide. But a current generally sets out through the Sound, occasioned, no doubt, by the rivers which empty themselves into the Baltic. These currents prevent stagnation in the Mediterranean and Baltic. Where tides do not act, a substitute is provided.

In connection with tides, we may mention the currents which abound in the ocean; and the causes of these phenomena are more numerous than at first sight might be imagined. They may be occasioned by the conformation of the coast or of the channel of the ocean, by a difference in heat or saltness, by the melting of the polar ices, or by the inequality of evaporation in different latitudes. Several of these causes may at times occur. The Gulf-stream is a remarkable current, which leaves the coast of Africa about the latitude of the Cape de Verd Islands, traverses the ocean to the American shore, sweeps the Gulf of Mexico, stretches north as far as the Bank of Newfoundland, in 41°, and turns eastward towards Madeira. It forms a great sea-river, in some places near eighty leagues broad. Its waters take about two years and ten months to perform their circuit; and, in some places of their course, are at a much higher temperature than the waters of the surrounding ocean.

3. The ocean is a great scene of animal existence and enjoyment; and it is preserved in a fit state for being so by its saltness and its tides. It is replenished with innumerable inhabitants, all fitted for the element in which they reside; and all, so far as we are capable of judging, enjoying a happiness suitable to their natures. Thus, I think, the ocean proves the existence of a powerful, wise, and good Intelligence, by the provision made for maintaining the salubrity of its waters, and by its innumerable inhabitants.

II. Let us glance at the purposes which the ocean serves in the system of our world.

Here we find it of essential importance. Without it the globe would be a barren and lifeless desert, presenting one uniform prospect of dismal sterility and melancholy silence; adorned by no verdure, and cheered by no busy scenes of life and enjoyment. To the ocean we are indebted for the beauty and fertility of the dry land. It is the great fountain of moisture; refreshing and fertilizing the earth, and furnishing an abundant and wholesome beverage to man and beast. Water is exhaled from the ocean; floats in the atmosphere in the form of vapor; and is precipitated in dew, hail, rain, or snow, supplying the aliment of vegetation to plants and herbs, and yielding a salubrious drink to living creatures. By the channel of the rivers it again returns to the bosom of the ocean; and in this circle it perpetually moves, supporting a great system of animal and vegetable existence. It deserves to be remarked, that water, although it proceeds from the sea, yet is fresh when it descends in rain. If much ingenuity be required to render sea-water sweet, shall we deny the wisdom of Him who constructed the great laboratory in which the process is carried on with unfailing precision and success, on the vast scale of nature? And if wisdom be displayed in the accomplishment of the end, that end is unquestionably a proof of goodness. It is the means of supplying a necessary aliment suited to our constitution, and to which, by admixture, we can communicate any taste or flavor that we please. The earth is so formed as to receive the water into reservoirs, to filtrate it, and to give it out in perennial streams, for the constant supply of our wants.

At first sight, the ocean seems an insurmountable barrier between different portions of the globe, separating them as effectually from each other as if they were parts of different planets. But we soon perceive that, even in this point of view, it harmonizes with the rest of the system, giving scope to human ingenuity, and inviting to the exercise of vigorous exertion. Men soon learn to commit themselves to the sea, and to combat winds and waves. Even before civilization is far advanced, intrepid skill or casual misfortune carries them to great distances, and spreads them widely over the face of the earth. The inhabitants of the far-scattered islands of the Pacific Ocean speak nearly the same language; and must all, at no very distant period, have sprung from a common origin, and diverged from a central point.

The ocean becomes the medium of a vast and boundless intercourse between nations. It facilitates the communication between the most distant parts of the earth, and the exchange of the commodities of different climates. No country is supplied with such a rich variety of the necessaries and accommodations of life, but that it may admit the introduction of foreign superfluities; and even the poorest furnishes materials for exportation. The ocean is the great medium of commercial intercourse. It also modifies the temperature of the atmosphere on the land, rendering it warmer than it would otherwise be in high latitudes, and cooling it in tropical climates. It is, also, an inexhaustible storehouse of human food.

How far, and in what particular manner, the ocean and the exhalations from it, contribute to the purification of the air that has been contaminated by the vegetation of plants, and the respiration of animals, I do not at present inquire; although I am satisfied that their operation, in this respect, is of essential importance. Thus wisdom and goodness appear in covering such a portion of the globe with water, and in preserving it from stagnation and putrefaction. In this way an inexhaustible fountain of moisture and fertilization is established; a fit place of residence for innumerable sentient beings is provided; the means of facilitating the intercourse of distant nations are devised; and a great storehouse is opened for supplying the wants and diversifying the enjoyments of man.

CHAPTER VII.

WATER, AS A CHEMICAL SUBSTANCE.

In addition to the obvious utility of water in supplying the basins of the ocean, and lakes, and the beds of rivers, there are so many striking evidences of design and goodness in the formation and utility of water, considered as a compound chemical substance, that we cannot with propriety withhold a somewhat extended consideration of it. What follows is from the gifted pen of J. K. Mitchell, M. D., of Philadelphia, to whom the science of chemistry is not a little indebted.

"One of the most abundant substances in the world, water is also one of the most useful, whether we view it in the agency of its elements, or in the milder actions of its compound state. Every where present, it is every where active, and the extent and variety of the phenomena presented by it are such as a life-time of observation could not note, nor a century of experience appreciate. This is itself a very striking fact; for if the very different and even opposite uses subserved by water, were fulfilled by as many various substances, either they would be scarce or inaccessible in many places, or, being all widely diffused, would stand in the way of each other, and encumber the beings they were made to benefit. Capable of assuming all the *forms* of matter, acting the part of a solid, a liquid, or a gas; susceptible of decomposition in to two potent constituents, water admits of a prodigious extent and variety of application. It is, although obedient to most of the laws by which other matter is governed, gifted with some singular exemptions, so obviously the effect of design as to have drawn forth a declaration to that effect from every one who has observed them. The most remarkable of these peculiarities is that which exempts water from obedience to a law otherwise universal, viz. that all liquids are expanded, though in different degrees, by the increase of their temperature. To this rule water is partially submissive; and from 40° F. up to its boiling point, it is constantly expanded by augmented temperature. But below 40°, the rule is violated, and the addition of heat invariably causes a contraction. Water, therefore, at, or very near to 40°, is the heaviest water; for, whether we heat or cool it, beginning at that temperature, it is increased in bulk, or lessened in specific gravity. For this reason the refrigeration of the surface of water makes that surface heavier, and it sinks into the warmer liquid below it, until the whole of the fluid in the vessel is reduced to the temperature of 40° F. Cooled below that point, the surface of water, contrary to the general law, becomes lighter as it loses heat, and remains at the top until its temperature falls to 32°, when it is transformed into ice. This very curious exception to a law, otherwise uniform in its application to liquids, appears to have been necessary to the welfare, and even the continued existence, of animals. Were water subject to the usual law of expansion by heat at all temperatures, the consequences would be disastrous. Before any ice could be formed in any river or lake, all its waters would be reduced to the freezing point—a temperature at which few aquatic animals could long survive. Then the place where ice would begin to form, would depend on accident, or the presence of solid bodies, around which, as *nuclei*, it would collect. But the fishes, being of the temperature of water, would form centres of aggregation, and become enveloped in ice, disabled from motion, and put to a cruel death.

The exception to the general law enables the heat of spring and summer to readily restore warmth to the water; for when the surface becomes warmer, it sinks into the colder though lighter liquid beneath, until the whole mass is raised again to 40°, when, the usual law becoming applicable, the warmer water remains at the top. If it were otherwise, the cold fluid at the bottom of a lake could not be brought near to the surface, and it would continue cold until the following winter, acquiring a still lower temperature; until finally the streams and lakes would become solid masses, mighty glaciers, untenanted themselves, and rendering uninhabitable the adjacent country. The population, if it could still exist, would not congregate on the river-courses and lake country, but would fly as far as possible from the desolate streams, which now, teeming with fishes, and covered with the white sails of commerce, afford to man delicious food and easily-acquired wealth.

Water offers, in freezing, another unusual exception to a general law. Most liquids, in passing to the solid state, are lessened in volume, or become heavier, so that solids usually, though not always, sink in their corresponding liquids. Thus lead, which is solid, sinks in melted lead. But water is expanded by congelation, and therefore ice floats and covers the lakes and rivers, during winter, with a solid crust, affording a bridge for migratory animals, and presenting to the escape of heat from the water below, a useful, though imperfect barrier. But the expansion of water in freezing is of still greater use. As winter approaches, the earth becomes wet with frequent rains; and 'when,' says the Indian proverb, 'the pools are full, the ice and snow will come.' Even the hardest and most compact soils are thus moistened. But the frost follows the water into the ground, converts every drop near the surface into ice, the expansion of which forces asunder the adherent particles of earth, and renders the soil loose and spongy for the better reception and nutrition of grass, seeds, and the roots of trees and shrubs. But for this singular property, how many cold and sterile wastes would frown, where now there is verdure and luxuriancy! In this manner, too, the more friable rocks are dilapidated, and afford materials for the creation or enrichment of soils, with much greater rapidity than under the less active forces of the other elements of decay.

No other liquid freezes at or about the temperature of the formation of ice, which takes place at 32° of Fahrenheit's thermometer. Mercury and ether are frozen at a temperature at least 71° lower; and alcohol has never yet been converted into a solid by any degree of cold, however great. But had the freezing point of water been materially different, what disastrous events would have mastered the world! If it were to freeze at a *higher* temperature, we should have the lakes and rivers in icy chains during the spring time and autumn; and our fields, instead of drinking in the genial showers of April, would often be covered with unfertilizing snow, when the plants and the flowers were looking up to the clouds for refreshment and food. The grass would be withdrawn from the reach of the ox and the horse, and the seeds would lie on the ground inaccessible to the birds, in the very season of maternal anxiety and care. Instead of the loose and friable soil, we should encounter, during the greater part of the year, a hard and unyielding crust, unfit for the reception of seeds or the stimulation of vegetable growth. If the freezing point were, on the other hand, considerably *lower*, still more terrible consequences would follow. Instead of reposing under the dry, light, and shielding snow of winter, the earth would often be deluged with water too cold for its living things; and they would perish. Think of getting wet in a shower at the temperature of 20° or 10°! But this water would penetrate the earth, and carry down its coldness beyond the reach of the summer sun, and chill the soil into barrenness and desolation. A thousand ills would spring from *any* material alteration of the freezing point of water; but, happily, that temperature was selected for it by Him who, foreseeing all things, has not forgotten the lightest matter in his multitudinous universe.

The *specific gravity* of water is the very best which could be given to it. If lighter, it would not be sufficiently buoyant for animals or ships; and if much heavier, the fishes could not remain beneath its surface. Any animal would sink in alcohol, or ether, or oil; and on a sea of mercury it would be impossible to ballast a ship with any thing but gold or platinum. Its gravity, therefore, is nicely proportioned to the weight of fishes and other animals, to the timber of which ships are built, and to the means of ballasting them.

Compared with that of other liquids, the capacity of water for heat is not a little remarkable. In passing through a given range of temperature, water absorbs nearly *thirty* times as much heat as the same weight of mercury, and about twice as much as alcohol, oil, or ether. The lakes, rivers, and oceans become, therefore, during summer, vast magazines of heat, cooling the air by their great capacity for caloric *heat,* and storing it up to be given out again when the temperature of the air declines. So that the waters resist sudden and great changes of temperature, both by imbibing and giving out, according to circumstances, a very large quantity of caloric; and as so large a portion of the terrestrial surface is occupied by water, the earth is not only made more habitable, but more healthful and agreeable. It is to this exorbitant capacity of water that we owe the land and sea breezes, by which tropical islands and coasts are so refreshingly fanned. For as the land, being of less capacity than water, is more quickly warmed by the sun, a sea breeze is created during the day; whilst, as, during the night, the land, for the same reason, cools faster, a land breeze is produced. This vast capacity preserves the waters from freezing to a much later period of winter, and tends to temper the march of spring, and to prevent sudden thaws and violent inundations. If the capacity of water for heat were low, the fluids of the deepest lakes would soon be reduced to the temperature necessary to form ice, and the lakes and rivers would be withdrawn for a much longer period of each year from the uses of commerce. But as the water holds so vast a quantity of heat, it maintains a long conflict with winter, and in some insular situations, tempers its severity for the whole season. Even when ice *is* formed, the process is useful in lessening the severity of cold; for the ice, being of much less capacity than water, yields up, in passing to a solid state, a very large quantity of caloric, which renders more difficult the solidification of the rest, and gives warmth to the surrounding air. For a like reason, the ice, as it melts into water in the spring, absorbs so great a quantity of caloric as to temper the onset of heat, and make the thaw gradual. Otherwise the liquefaction would be sudden, and floods of great extent and irresistible force would desolate, in the spring, the countries adjacent to the streams.

There are many phenomena connected with the *ebullition* of water equally worthy of the notice of the philosophical theologian. Among these is the *temperature* of boiling water. If that temperature had been much *lower* than it is, we should have been unable to use water as a culinary agent. Its power of destroying the hardness and cohesion of animal and vegetable substances would be annulled, and we should be deprived of many agreeable and even necessary articles of

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food. The Augustine monks, who live on the top of the Great St. Bernard, complain of the scarcity of fuel, as being particularly inconvenient to them, because the water used in cooking food, boils there at so low a temperature as to require a very prolonged application of heat, and a consequent profuse expenditure of fuel. Travellers acquainted with the subject ought long since to have rectified this evil, by telling them to put salt into the water, for all such processes as are compatible with its presence, and in other cases to apply pressure. Were the temperature of boiling water much *higher* than it now is, we should be deprived of the advantage at present derived from many convenient materials used in the construction of culinary instruments, whose safety depends on the limitation of heat by the escape of vapor. But the particular temperature at which water boils is far removed from that of the ebullition of any other liquid. Ether boils at 98° F., alcohol at 173°. 5, spirits of turpentine at 316°, and mercury and oil at from 649° to 650°.

The vapor of water requires, for its production and continuance, a remarkable quantity of heat. A pound of steam, although of the same temperature as boiling water, holds enough of caloric to make a pound of water red hot, if it were possible to keep the water liquid at such a heat. This is proved by forcing the steam into ten pounds of water, which will be raised to 100 degrees; but if ten pounds are raised to 100, one pound would be raised to 1000 degrees; and that is a temperature visibly red in the day-time. There is no other liquid whose vapor is endowed with any thing like the same degree of power of absorbing heat; hence this may be enumerated among the many peculiarities of water.

Water does not give off vapor alone at the boiling point. Even ice yields a portion of steam, and at all ordinary temperatures evaporation is in action. Less when the water is cold, it augments as the temperature is increased, until at 212° it is as rapid as possible. The extraordinary absorption of heat by vapor necessarily renders evaporation a cooling process; and as the quantity of vapor is proportional nearly to the heat, so is the refrigeration. To this property of water we are indebted for the possibility of living in tropical regions, and for much of the coolness of the summers of more temperate zones. We are naturally surprised at observing that the breeze which cools our bodies produces no effect of that kind on the thermometer; but our wonder ceases, when we consider that the moisture on the skin is vaporized, and that the vapor absorbs a great quantity of heat, while the thermometer, being dry, is only of the temperature of the air, whether still or in motion. A few drops of water, placed on its bulb, will enable the breeze to lower its mercurial column, and prove that evaporation is a cooling process. In climates in which ice is not formed, the inhabitants cool wine and other liquids by wetting the vessels which contain them, and placing them in a rapid current of air. The power of quenching flame and extinguishing fire, so remarkable in water, depends mainly on the refrigerating action of the steam. If steam were formed only at high temperatures, we should never be able to throw enough of water on a conflagration to arrest its progress. On the other hand, if the boiling point were as low as that of ether, we should be frozen even in summer, as may be demonstrated by the familiar experiment of solidifying water by the evaporation of ether from its surface.

As the formation of vapor cools the plains and the valleys, so its liquefaction or solidification tempers the severity of the coldness of mountains and table lands. Rain affords heat, as it is formed out of vapor, and the production of snow is only effected by the discharge of a great amount of caloric Hence we say, 'It is too cold for snow,' because we always observe, even at the surface of the earth, the warming influence of the radiant caloric which comes down from the snow-clouds as invisible particles are aggregating into snow-flakes. It is highly probable that the heat, extricated by the snow which is first formed, prevents the degree of cold by which more might be produced, and thus sets a limit to the quantity, and prevents a too heavy fall, by which the earth might be covered to an inconvenient or destructive depth. Were it not for the immense evolution of heat when rain and snow are formed, the mountains and higher table lands would not be habitable. But the air of these lofty regions is continually warmed by the caloric, which, brought up by evaporation from the sultry plains and valleys, is extricated in the middle air by the rain-drop and the snow-flake.

Thus water is, as it were, the regulator or balance-wheel of temperature, acting on the production and limitation of heat, as the governor of a steam engine does on the admission of vapor and the movements of the machinery.

The *solvent powers* of water are very various and extensive With the exception of a very few earths and some metals almost every thing terrestrial is soluble in water. In the springs and rivers, therefore, we find traces of numerous substances usually solid—lime, magnesia, oxides and salts of metals, soda, potassa, muriatic, sulphuric, carbonic acids, animal and vegetable products, and a great variety of simple and compounded gases. Besides the solvent property, water has, from its *peculiar specific gravity*, the power of holding in mere mechanical suspension the parts of soils of most fertilizing efficacy. By means of these properties this wonderful liquid is able to bring up from the deep recesses of the earth, and down from the inaccessible hills, the ruins of rocks and soils, to enrich the surface, and to extend agricultural districts. By imbibing, too, the most active constituents of the atmosphere, which it does in a peculiarly high degree, water carries carbonic acid and oxygen to the roots of vegetables, and thus contributes to the improvement of the nutritious qualities of the soil.

Next to oxygen,* the most important substance held in solution in water, is common salt (chloride of sodium); and of all solids, common salt is most potent in lowering the freezing temperature of water. It is undoubtedly for *this* reason among others, that the great deep is filled with salt; for the many evils to ensue from a frozen ocean are obvious. It is certain that fresh water seas near the poles of the earth would become entirely solid; the frozen mass would extend by degrees towards the south; and it is far from demonstrable that the very equatorial regions would not become submissive to the sway of a perpetual winter. But there is one very important reason for the saltness of the ocean which has been commonly overlooked. The gas called carbonic acid, or fixed air, is one of the constituents of the atmosphere, which has, as such, a variety of uses. Fresh water absorbs its own volume or measure of this gas, and for that reason carbonic acid is proportionably less near to the surface of the earth than in higher regions. If, in addition to the absorbent power of lakes, rivers, and spongy soils, the ocean were to act on carbonic acid with its vastly-extended surface, there would be soon perceived a great deficiency of this gas, which is the food of plants, the enlivener of water, the neutralizer of lime, and of the oxides. But brine, or water holding salts in solution, does not readily absorb carbonic acid, even when the gas is pure; much less will it abstract it from the vast disproportion of common air with which it is commingled. Nay, more; from some experiments I have recently made, I am entitled to believe that when the fresh waters, charged with

* Oxygen is that gas which enters into the composition of atmospheric air, and this latter, in virtue of it, is fitted for respiration and supporting combustion, &c.

carbonic acid and oxygen, roll their enriching streams to the ocean, the briny floods compel them to disgorge the portion of these gaseous treasures which had escaped the respiratory organs of the fishes, and the absorbent vessels of aquatic plants. Thus the ocean restores to the atmosphere what had been taken from it by the streams; and the air, impoverished by the lakes and rivers, becomes again enriched by the bounty of the ocean.

Salt is an indispensable article of food, as necessary to life as air or water. Its universal distribution is due to the water of the ocean, which brings it from the deep recesses of the earth to the shores of every land. Water is the only known liquid capable of so diffusing it; for in pure alcohol, or ether, or mercury, it is totally insoluble.

Salt water has but little power of penetrating into the minute interstices of bodies, so that any thing of a fine porous texture remains in it unchanged for a long time; and as the gases are not, at least in large proportion, present in brine, salt water is eminently preservative. It acts feebly itself, and does not convey destructive agents; hence seeds of plants float over the ocean thousands of miles to the islands which adorn its face, and there, meeting with soil and fresh water, beautify and improve the country of their adoption. In a fresh water ocean, they would germinate, rot, and perish, long before such a voyage could be completed.

For the same reason, salt water does not readily sink into the porous earth of the sides and bottoms of the great oceans. The unfathomable depth of the sea, and the consequent vastness of the pressure on its bottom, would, but for its saltness, force the water far and wide into the recesses of the earth, and withdraw a large portion of it from its present situation. At the same time, if salt water were as penetrant as fresh water, there would be scarcely a spring but of brine—scarcely a fountain but what would savor of Neptunian influence. But while the salt detains the water from the pores of the earth, it has little power of withholding it from the fields of air. Evaporation goes on from the surface of the great deep with little interruption from the salts which are there in solution; and the vapor leaves them so entirely, that not often can there be detected the slightest adulteration, even at its source. From this mighty magazine of water much of the liquid is conveyed to the higher regions of the air, to be precipitated in fertilizing and saltless rain or dew on the continents and islands. Dr. Thomson has made very elaborate calculations to show that one ninth of the rain which falls in Great

Britain must be furnished by the ocean, because the evaporation, even from the watery surface of England, is that much less than the quantity of rain annually precipitated on it. The ocean annually sends, therefore, to enrich the soil of Great Britain, nearly eighteen billions of tons of water—a quantity sufficient to cover the whole surface of the island four inches deep.

Fishes breathe the same air that is respired by ourselves; but it is only when held in solution in water that they are able to transmit it through the gills, which serve in them the same purpose as lungs. Water is invested with the power of absorbing and holding air in solution; and indeed it is said, on good authority, that oxygen is absorbed in greater proportion than nitrogen,* and that in rain water there is more than in common water, and that snow water holds most of all. Besides the still surfaces of deep rivers, and of great lakes, which are continually absorbing air, that fertilizing and vivifying fluid is forced into more rapid commixture with water at the ripples and waterfalls. In such places, for this, among other reasons, aquatic animals love to congregate and to sport; and it is thither the skilful angler repairs, to exhibit his baits, and to decoy his victims.

It is known that when water is heated to 212° Fahr., it begins to boil, and that a portion of it is forced off in the condition of subtile elastic vapor called steam. Most persons have also observed that, much below the boiling temperature, a visible vapor is given off by water; and the more observant have discovered that, at common temperatures, water is gradually but imperceptibly removed from an open vessel, and dissipated into thin air. But it is only those who have studied this subject, who are aware that at any temperature, however low, water is ever disposed to escape into the air, and that even ice gives off vapor of sensible elasticity. But the rate of evaporation being made dependent, not on the air, as is commonly believed, but on the temperature, it is at $18\frac{1}{2}$ Fahr. only as 2; at 38° as 4; at $79\frac{1}{2}$ as 16; at 100° as 32, and at 212°, the boiling point, 512. If it depended on the attraction of the air, and went on as rapidly in cold as in warm climates, the former would be plundered of its caloric, and its regions become deserted and desolate. Another evil would be, the enormous amount of snow which would in winter cover the northern plains of Europe and America,

* Nitrogen, or azote, is another constituent element of atmospheric air, different from ogygen: its effects are chiefly negative. It would seem to serve as a diluent of oxygen.

bury them beyond the recovery of their longest summer, and by gradual change of climate encroach on, and confine to narrow limits some of the now most delicious regions of the earth. In tropical climates, the rain which falls annually may be rated at from 80 to 125 inches; in temperate regions, at from 30 to 40 inches, or less than one half; and in cold countries, at from 10 to 20, or less than one sixth. Now, as the rain is a pretty good gauge of the evaporation, the refrigerating process is, in very cold climates, one sixth, and in temperate ones one half, of the amount of that which obtains in the torrid zone.

As there is a cogent reason for almost inadequate evaporation in cold countries, the rain in them descends in gentle and prolonged showers or in very irrigating mists. Very little of the water, therefore, escapes over the surface, so as to be lost; but most of it quietly sinks into the earth, and moistens the roots of plants and flowers, or flows out again through springs and fountains. But in tropical countries, where, for refrigerating uses, too much water loads the air, it is precipitated to the earth in impetuous showers, and flowing rapidly over the soil, escapes by the streams and rivers to the ocean. Hence we observe that the number of rainy days is smallest at the equator, and increases as we advance towards the poles. From north latitude 12° to 43°, the mean number of rainy days is 78; from 43° to 46°, 103; from 46° to 50°, 134; and from 50° to 60°, 161. The number of rainy days, then, is, in latitude 60°, rather more than double that, at or near the equator; while, at the same time, the quantity of rain at the equator is five or six times as great as at 60°. Evaporation, for the uses of the world, should be greatest in warm, and least in cold climates; and it is so, both because of the influence of heat in promoting, and of moist weather in retarding it.

Were the rain to fall in tropical regions as it does in higher latitudes, the total destruction of animated things would inevitably ensue. Plants would perish in their own luxuriancy, or, blighted by mildew, be sacrificed to the parasitic vegetables fastened to their leaves, blossoms, and fruits, by the excessive moisture. Animals, no longer able to throw off the redundant moisture of the body, by the skin and the lungs, into an air already saturated with water, would become lymphatic, excessively glandular, and diseases of loathsome and lingering aspect would desolate the tropical regions. But, suddenly precipitated from the air, the moisture is speedily reduced far below the point of saturation—the 'dew point'; and then a more rapid evaporation from the earth, and the surface of animated bodies, tempers the breath of a burning clime, and renders not only habitable, but agreeable, regions of the world where, but for this curious distinction, none but aquatic animals or reptiles could exist.

When the vapor escapes from water, and begins to ascend in the air, it soon reaches a higher and colder place in the atmosphere, and might be reconverted into water, and fall back almost immediately into the sea, or other source of supply. But, under the operation of yet unknown causes, the vapor, instead of aggregating into drops of spherical shape and considerable density, is inflated into thin, filmy vesicles, little bladders of water, filled with air, which, of nearly the same gravity with the air of the cloud region, float in curiously-congregated masses to even distant countries, and there, suddenly bursting by means equally unknown, they descend in drops of rain. It is to this very singular property of watery vapor that we are indebted for all that rain which is received by the land from the ocean, and for the shadows which clouds spread over a 'weary land.' The elder Saussure saw, in the high Alps, these vesicles floating around him; and, although many of them were very small, some were as large as a pea, and, of course, large enough to bear ocular examination. If the clouds were not formed of such vesicles, we should see a rainbow *in* every one, when the observer stood between it and the sun. But it is only to the *dissolution* of the cloud that we are indebted for the magnificent security against a future flood,—"the bow of heaven complete,"—set in the fields of ether as a signal expression of the divine will that there shall not again be drawn over the fair face of nature the deforming veil of the deluge.

Independently of clouds and *visible* vapor, the very driest atmosphere contains a considerable quantity of water, in a perfectly aeriform state. This invisible aqueous air varies in quantity in different places, and in the same place at different times. Amidst the burning wastes of Africa, it is so little as to be scarcely appreciable; while, in the winter, on the stormy coast of western Scotland, the atmospheric air is almost always saturated with it. That its presence is necessary to plants, every one knows, who has observed their shrivelled aspect in an arid summer, even when carefully watered at the roots; and he who has been compelled to bury his face in the earth to escape the fiery breath of the simoom, knows how intolerable is the purest atmosphere from which water is excluded. From this invisible vapor, of which I have just spoken, is derived the dew of a clear evening, the big drops which trickle down the tumbler, when, in summer, cold water is poured into it, the mist which hovers over the cold stream, and the vapor which enshrouds an iceberg. But the vapor which is put to so many important uses, and is so agreeable to the skin and the lungs, gratifies also another sense. That blueness of the firmament—that bright and beautiful blue, sung by so many poets, likened to so many eyes, the chief glory of an Italian landscape—is the offspring of the vapor of water; and the traveller of the highest Alps knows, that when he has surmounted the region of water, in his perilous journey, the heavens become black and sombrous, and the bright stars are seen in a sky of jet. The same water, therefore, which is exhaled for rain and dew, tempers the air for the tender leaflet and the unfolding blossom, enriches it for the breath, makes it balmy for the skin, and tints it with an exquisite color for the gratification of the eye. Perfectly inodorous itself, the moisture of the air is the constant vehicle of the sweetest perfumes, most of which are incapable of assuming an aerial state without its agency. How quickly we perceive the fragrance of the parterre after a shower! and how rich is the odor of the woodland when the spring rain has waked its sweetness! But there is another curious function performed by the atmospheric vapor. By means, most of which are yet unknown to philosophy, a great quantity of electricity is collected in the atmosphere. Among the *known* causes of its presence, there may be enumerated the ascent of vapor, the friction of currents of air against each other, and against the plains and mountains of the terrestrial surface. In whatever manner conveyed thither, we know that it is concentrated by the gradual coalescence of vapor as it fashions itself into clouds, and that thence, when the tension is beyond the capacity of its recipient, the lightning dashes out from the thunder-cloud, either to the earth from which it came, or into some other feebly-charged 'pavilion of darkness.' At some of the uses of these mighty manifestations of the sublime, we can only vaguely guess; but there are others of plainest import. If it is as yet a hypothesis, that electrical agency converts into carbonic acid and water hurtful, combustible impurities, forever rising into the air from stagnant pools, extended morasses, and the thousand sources of oxidizement by the decomposition of water, still it is certain that, after a thunder-storm, the heavens are serener; the sky brighter; the air cooler; the verdure more varied; the flowers fresher; and man himself more vigorous and elastic. There is not, after a thunder-gust, that humid feeling in the

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breath of nature, which follows a wintry rain; but the electrical battery, expelling every redundant particle of moisture, gives to the breeze its most exhilarating qualities. It is, then, to the batteries of vapor, terrible as they are, that we are indebted for the exemption which our summer months claim from mists, and prolonged rains, and for the perfect precipitation of moisture, and the subsequent rapid evaporation. They are the chief cause of the balm, the dryness, and the coolness of the breath of summer; and but for them, how many gardens of the south would be turned into desolated wilds!

The *chemical* history of water is equally curious and instructive. The soft, bland, nutritious liquid is not, as supposed by the ancients, and even our immediate progenitors, a simple or uncompounded substance, but it infolds in its mild bosom two of the most formidable elements to be found in the storehouse of nature. Oxygen, the chief agent of combustion, the very king of fire, and hydrogen, the most inflammable of gases, are the constituents of the water which quenches flame and extinguishes combustion. Tied together by the bonds of affinity, these two substances are continually separated from each other by the many things which have attraction for either. In this manner, both of the constituents of water exert a most important influence over the chemistry of nature. It is at the expense of the oxygen of water that metals are rusted and reduced to an earthy state; for it seldom happens that the air gives oxygen for such purposes. It is by the decomposition of water that plants are enabled to give back to the atmosphere the oxygen which has been removed by the respiration of animals, and thus to sustain the purity of the air. As we advance in the process of investigation, we shall learn that most chemical phenomena are explicable chiefly by the reaction of water or its elements. Water gives to solids the liquid state essential to their mutual action; for neither the solid nor aeriform state is favorable to chemical changes. Water, by its powers of solution and evaporation, first impresses on a solid a liquid character, and then, by slowly abandoning it, gives it time to aggregate in a harmonious order; and thence we derive the pleasure and the profit of crystallography.

Water, endowed with extraordinary absorbent power, especially for the deleterious gases, removes them from the air as fast as they are produced; and thus it is that carbonic acid, sulphureted hydrogen, muriatic acid, sulphurous acid, and chlorine, have been prevented from long since rendering the fair earth on which we dwell a sterile waste. It is water which, holding in solution the aliment of plants and animals, is the source of their vigor and beauty. Penetrating animal and vegetable tissues with a facility *given to no other liquid*, it is able to carry with it a portion of food into the deepest recesses of life. What enables the blood to flow in veins and arteries? Water. What swells out the sap-vessels of plants, brings out the sugar from the maple and cane, and thrusts forth the incense from out the rose and the shrub? It is water. What gives to the 'human form divine' its plumpness and symmetry? Water, water. A dried plant weighs but a small fraction of a green one, and a human being of 125 lbs. was, when dried thoroughly, only of the weight of 18 lbs.; the rest was *water*. But for the water which lodges in the membranes and blood-vessels of the lungs, the carbonic acid would not leave the blood, and the vital stream could not long continue to nourish the frame and invigorate the organs.—But this is not all. Water abounds in every part of plants and animals, and is constantly undergoing decomposition, imparting one element to one organ, another to another—becoming, as water or its elements, a constituent part of bone, muscle, nerve, sinew. Few of the acids can exist, at least usefully, without the assistance of water. It is essential to the existence of aquafortis; gives all its extraordinary utility to oil of vitriol; adds all its valuable qualities to marine acid, and prevents vinegar from either becoming solid or perishing. But I am now on a catalogue of almost infinite extent and importance, and a bare enunciation of the peculiar chemical agency of water would fill a volume.

It is a favorite maxim of natural theologists, that the Great Builder of the universe created things not only for nature, but the arts; and that he impressed on matter properties, not only to serve in the great field of spontaneous action, but to become submissive, at a distant day, to the artist, for the promotion of the comfort and improvement of man; for example, that the faithfulness of the dog, and the docility of the horse, were to be the future means of attachment and submission; that the malleability of gold, the toughness of iron, and the hardness of steel, were but preparation for the gilder, the wheelwright, and the cutler. On the same principle, we perceive, in the very peculiar qualities of the vapor of water, a nice and discriminating adaptation to the future wants of highly-civilized man. No other steam but that of water could give impulsion to the steam engine. Either too corrosive, or too dense, or of too great a temperature, the vapors of acids, or of ether, or alcohol, or mercury, could not be made applicable to the propulsion of a boat, or the progression of a car. As there is no faithful guardian but the dog, no useful courser but the horse, so there is no propeller of locomotives but steam. At precisely the heat of steam of low pressure, there is not such an excess of temperature as to very rapidly convey it to surrounding objects; but if we were compelled to double the heat every time we duplicated the power, we should have feeble engines, in the place of the potent machinery now at our command. At 212° above zero, steam equals in power the pressure of one atmosphere, that is, 15 lbs., on each square inch; and to make even a low-pressure engine work well, it must have a steam equal to nearly half an atmosphere more; but if a *proportional* heat were necessary, the temperature would be not less than 303°, at which the loss, from the contact of air and from radiant diffusion, would be immense. But to work a high-pressure engine, the form of the instrument indispensable to locomotives, the heat necessary for action would be from 1000° to 1600 or 1700°, at the lowest of which temperatures, we should have red-hot boilers, red-hot cylinders, unpacked joints, corroded surfaces, abundance of hydrogen, frequent explosions, and the abandonment of expensive and almost unmanageable engines. But, providentially, the density of steam is much more than proportionally increased by increasing temperature; and although steam of one atmosphere is at 212° of Fahr., steam of two atmospheres is only at 250°; of three atmospheres, at 272°; of four atmospheres, at 290°; or, while 212° are required to produce an effect equal to 1, only 40° more are necessary to produce an effect equal to 2; 22° to produce 3; and 18° to produce 4. Or, rising from 275°, 18° of increased temperature give an effect equal to that created by an elevation of 212°, counting from zero; and at or near to a temperature the double of that of boiling water, steam exerts a power about 40 or 50 times as great; affording, at a heat easily borne by metals, and not destructive to the 'stuffing' of joints, a steam much more than adequate to the production of all desirable power.

The enormous capacity of water for heat is of the highest importance to the usefulness of the steam engine. If water had a low capacity, its temperature would be too easily altered by fire, and sudden and explosive productions of steam would continually endanger the safety of the boiler. Such a result is readily perceived when we heat ether or mercury. But as water absorbs a great quantity of heat during its elevation to higher temperatures, the inequality of the action of fire is less perceptible and less dangerous. Again, if steam did not exhibit an *equally* high capacity for caloric, it would be almost impossible to keep the piston in motion. As it is, a very small quantity of steam affords heat enough to keep up the temperature of the cylinder and piston, while the remainder propels the engine; but if it were of low capacity, the iron would condense the greater part of the vapor, and leave a quantity inadequate to the production of useful motion. As the temperature rose in the engines of higher pressure, the evil would become greater and greater; and, at length, the steam would be incapable of supplying heat enough to keep up the temperature of the cylinder, and the machinery would cease to move.

Steam is a remarkably light vapor—a matter of greater consequence than is at first sight apparent. The vapor of water is a very little more than half as heavy as air; that of alcohol is three times, and of ether nearly five times as heavy as steam.* The great levity of watery vapor carries it immediately away from the surface where it is produced, and thus frees the earth from its excess of moisture; but the vapor of ether falls immediately downwards, as may be perceived by looking towards a window through a stream of it, as it escapes from an uncorked bottle. If steam were not among the very lightest of vapors, it would forever saturate the lower regions of the air, fill all the valleys, and finally infold even the mountains in its damp embrace, and prove as disastrous as the deluge itself, without affording a medium on which one single ark could float. The *levity* of watery vapor gives to it particular adaptation, too, to the propulsion of machinery. Every one who has used a forcing-pump to condense different gases, must have perceived that the task becomes more difficult as heavier gases are driven forward, and that the condensation, particularly easy with hydrogen, is very laborious with air or carbonic acid. In escaping from the same pipe, under equal pressure, hydrogen moves more than three times as rapidly as carbonic acid. These singularities arise from both augmented friction, and greater weight of matter to be moved. When, then, steam, for the movement of an engine, is produced, it escapes with facility from the boiler into the cylinder; and through a pipe made narrow, to lessen weight, expense, and refrigeration, a very large volume of vapor rushes against the piston, follows it with ease,

* Vapor of water, 0.62349; absolute alcohol, 1.606050; sub ether, 2.5860; oil of turpentine, 5.0130.—*Gay Lussac.*

and with the velocity of lightning, is either expelled into the air, or drawn towards the condenser. An increased resistance, such as the vapor of ether would make, along the whole line of operations, from boiler to condenser, would be a great addition to the expense, and no small detraction from the efficiency of the steam engine.

Thus, then, wherever we trace water, from the vast depths of ocean to the lofty fields of air, from the gushing fountains to the majestic rivers and the mighty lakes, from its liquid to its solid state, from its icy hardness to its airy softness, in the rainbow of the shower and the blue of the firmament, thundering over the rocks of the cataract, or floating in tiny vesicles in the regions of storm and cloud, collecting the waste electricity of the air, to send it back in sublime power to the earth, regulating the temperature of earth and air, cooling the breath, regaling the smell, and gladdening the eye—wherever, I say, we trace water, it is ever useful; fulfiling, as a minister of His goodness, the will of the great Contriver of the universe, and affording the most astonishing proofs of his wisdom as well as of his power.

It would require a volume to furnish the most cursory notice of the *known* phenomena of water, all of them equally illustrative of the wisest and kindest agency; but how much remains yet unknown, time and progressive philosophy can alone demonstrate. In the aqueous processes immediately around us, are many things not yet dreamed of in our philosophy; how many more in the fields of air, and amidst the unfathomed caves of ocean! The expanse of the higher atmosphere is seldom visited by man, and the fountains of the great deep, as well as the windows of heaven, have not been opened to his inspection. What we do know, however, is evidence of a principle of action exerted as benevolently and as sagaciously in every part of the physical universe; and we cannot doubt that 'The *firmament* showeth his handiwork, and the *earth* is full of the goodness of the Lord.' "

CHAPTER VIII.

THE GENERAL APPEARANCE OF THE EARTH, AND VEGETATION.

Had man and the inferior animals been cast upon a globe where sterility had established a perpetual empire, where no torrent rushed from the mountain, no shower dropped on the field, and no crops waved on the plain, they must have perished. Deep and mournful silence must have reigned on the dreary landscape, without any thing to enliven the solitude or diversify the sad uniformity of the scene. But the earth is liberally provided with means of subsistence to its numerous and various inhabitants. It exhibits a variety fitted to charm the imagination, to exercise the industry and ingenuity, to supply the wants and multiply the enjoyments of man. It is a rich storehouse, abundantly furnished with necessaries and comforts for every living being which it contains. It is indented by arms of the sea, which bring the treasures of the deep into the bosom of the dry land: it is watered by rivers, which at once drain off superfluous moisture and spread the aliment of vegetation over their banks, and which facilitate the communication between inland countries and the sea, and between the different places contiguous to their stream. Its surface abounds with gentle undulations; sometimes sinks into deep valleys, or rises into lofty mountains; but, generally speaking, the farther it recedes from the ocean, the higher it rises above the level of the waters; so that rivers run towards the sea, and, in most cases, marshes may be drained. The high lands serve as a reservoir for supplying springs and rivers, and shelter the lower grounds. The mountain and the valley furnish each a proper soil for plants of different kinds.

Even the bowels of the earth are replenished with materials which can be turned to the comfort and accommodation of mankind. Thence is digged the ore of iron, the most useful, and the most abundant also, of all the metals. There are found gold and silver which serve as the medium of exchange. Several minerals are possessed of much medicinal virtue; and some fossil substances serve for fuel and other valuable purposes. The face of the earth is adorned and enriched with a great variety of vegetables, each propagating its kind; for every plant, as well as every animal, proceeds in one way or another from a parent of the same kind with itself. The doctrine of equivocal generation exists only in the visions of an unenlightened imagination: it has no place in the provinces of nature.

The anatomy and physiology of vegetables might furnish us, even in the present imperfect state of our knowledge of these subjects, with many curious and interesting observations; but I purpose merely to make a few remarks, in order to show that the hand of the wise and good Being who manifests himself in the creation of animals, is equally apparent in the vegetable kingdom.

Every vegetable is capable of bearing seed; and seed, when properly deposited, becomes the germ of future plants. In many instances, plants may be multiplied in different ways; but we must look to seeds as the great means by which vegetables are propagated. And what a wonderful thing is a seed!* Why does it germinate more than a grain of sand on the shore, or a pebble in the channel of the brook? Must we not account for its configuration and vegetable power by resorting to a wise and good *First Cause?* Without the admission of such a cause, vegetable as well as animal life sets us completely at defiance. For the first seeds, then, we must have recourse to the great Intelligence who stands at the head of the universe; and in his power, wisdom, and goodness only, can we discover an adequate cause for that constitution of things by which seeds vegetate and continue their kinds.

In order to vegetation, many independent conditions must meet together. We must have seed, and, generally speaking, a vegetable mould. If the surface of the dry land had been one continuous plate of granite, it could not have afforded nourishment to seed; it could not have imbibed moisture; no verdure could have adorned the hill, and no crop

* "The *seed*, the last production of vigorous vegetation, is wonderfully diversified in form. Being of the highest importance to the resources of nature, it is defended, above all other parts of the plant, by soft, pulpy substances, as in the esculent fruits; by thick membranes, as in the leguminous vegetables, and by hard shells, or a thick epidermis, as in the palms and grasses.

"In every seed there is to be distinguished, first, the *organ of nourishment;* secondly, the nascent plant, or the *plume;* thirdly, the nascent root, or the *radicle.*

"In the common garden bean, the organ of nourishment is divided into two lobes called *cotyledons:* the plume is the small white point between the upper part of the lobes; and the radicle is the small curved cone at their base.

"In wheat, and in many of the grasses, the organ of nourishment is a single part, and these plants are called *monocotyledonous.* In other cases, it consists of more than two parts, when the plants are called *polycotyledonous.* In the greater number of instances, it is, however, simply divided into two, and is *dicotyledonous.*

"The matter of the seed, when examined in its common state, appears dead and inert; it exhibits neither the forms nor the functions of life. But let it be acted upon by moisture, heat, and air, and its organized powers are soon distinctly developed. The cotyledons expand, the membranes burst, the radicle acquires new matter, descends into the soil, and the plume rises towards the free air. By degrees, the organs of nourishment of dicotyledonous plants become vascular, and are converted into seed-leaves, and the perfect plant appears above the soil. Nature has provided the elements of germination on every part of the surface; water, and pure air, and heat, are universally active, and the means for the preservation and multiplication of life are at once simple and grand."—*Sir H. Davy's Elements of Agricultural Chemistry,* 2d ed. p. 70.—*Paxton.*

could have gladdened the plain; but a vegetable soil is provided. Water also must be present; for if seeds be dried, and moisture completely excluded, they will not germinate. As moisture, then, is requisite, this connects every seed with the ocean, the great fountain of waters. But seed, soil, and moisture, will not of themselves produce a single plant. There must be a certain degree of heat also; for no seed will germinate and grow below the freezing point. This connects every seed with the sun, the source of heat in our system. Yet, after we have found seed, soil, moisture, and heat, something further is still requisite in order to vegetation. We must have air, atmospheric air, or something nearly resembling it; for seeds will not germinate, and plants will not grow, under the exhausted receiver of an air-pump, nor without the presence of oxygen gas: the proportion of oxygen gas in atmospheric air is more favorable to germination than any other. Besides, the presence of light is requisite to give plants their peculiar color and flavor.* Thus to light, and to the atmosphere which surrounds the earth, are we indebted for the beauty that adorns it.

It is evident, then, that, before we can procure a single stalk of grass, many conditions are requisite, and the existence of any one of those conditions does not necessarily involve the existence of any other. They are independent upon each other. We can conceive a globe to have existed without a vegetable soil; a vegetable soil, without a seed; seed, without the sun; the sun, without the ocean; the ocean, without the atmosphere. But all these are requisite in order to germination and vegetation. What but a designing cause could assemble and combine all these independent conditions, so as to exert a harmonious action in the accomplishment of an important end? If the means be adequate to the end, the designing cause must be wise; for in what does

* The late Professor Robison of Edinburgh brought up from a coal-pit some whitish-looking plants; but nobody knew what they were. On being allowed to grow in the light, the white leaves dropped off, and were succeeded by green buds. It then appeared that the plants were *tansy*. On further inquiry, he learned that the sods on which the plants grew had been taken down into the pit from a garden in the neighborhood. Although the plant continued to grow in its new situation, yet neither in color, odor, nor combustibility, did it at all resemble plants of the same species which had vegetated under exposure to light. He made the experiment with great care, on lovage, mint, and other plants. They all throve in darkness, but with a blanched foliage, no way resembling the ordinary foliage of the respective plants. Even after the green color in plants is formed, it disappears on the exclusion of light.

Captain Parry, in his First Voyage, tells us, that, at Melville Island, he raised mustard and cress in his cabin by the heat of the stove: they were colorless from want of light, but had much of the same pungent, aromatic taste as if they had grown in ordinary circumstances.

wisdom consist but in choosing right ends, and in employing proper means for the accomplishment of those ends? And if the end promote the comfort and happiness of sentient beings, then the designing cause must be good; for the diffusion of happiness is the characteristic feature in the attribute of goodness.

Seeds consist essentially of three parts; a *cotyledon* or *cotyledons*, a *radicle*, and a *plumula*. [Pl. XXIII. fig. 5.]* The cotyledons constitute the most bulky part of the seed; and as the yolk of the egg nourishes the embryo chick, so they contain a quantity of food for nourishing the embryo plant, till by means of its radicle and plumula, which become the root and the stem, it is able to absorb nourishment from the earth and the air.

The food laid up in the cotyledons nourishes the radicle, which increases in size, and is converted into a root. The cotyledons now assume the appearance of leaves, and show themselves above the ground, forming what are called the *seminal leaves* of the plant. The roots absorb food from the earth; but this food, before it can be applied to the purposes of vegetation, requires to be digested. This process it undergoes, at first, in the seminal leaves. It is then carried to the plumula, which increases in size, rises out of the earth, becomes the stem of the plant, and puts forth branches and leaves. The seminal leaves now become useless, and decay and drop off; but the plant cannot be deprived of them sooner without destruction.

When thus perfect in all its parts, the young plant continues to absorb food from the earth. This food, under the name of *sap*, is conveyed in appropriate vessels to the leaves, where it is digested, and converted into the peculiar juice of the plant. The sap, after undergoing digestion in the leaves, is returned to nourish and increase the plant, which it does by depositing a layer of new matter round the old wood.

* The seeds of plants are enclosed in a capsule [Pl. XXIII. fig. 1.], which is comparatively strong. From the capsule projects a tube for the purpose of conveying the farina of flowers to the seeds, and without which they could not be productive. If the pistils are shorter than the stamens, the flower is erect, and the pollen, as it falls, is caught on the stigmas, and thus passes through the tube or filament into the capsule. [Pl. XXIII. fig. 2.] Where the stamens are shorter than the pistils, the flower is inverted, that the pollen may fall on the protruded part of the pistils as it drops to the ground. [Pl. XXIII. fig. 3.] In some cases, as in the nigella [Pl. XXIII. fig. 4.], when the styles are disproportionably long, they bend down their extremities upon the anthers, to receive the principle of fructification.

In plants of the class *diœcia*, the pollen is wafted by winds, or carried by the insects who are in search of food, from the nectaries of flowers. This is a remarkable provision, without which many plants would become extinct.

The new layer, or unhardened wood of the present year, is named *alburnum.* It is probable that the food, extracted from the earth, is imbibed by the extremities of the roots only. How this food is made to enter into the roots and ascend through the sap-vessels, I do not pretend to explain. The fact is certain; and whether we attempt to account for it by *capillary attraction*, or any other way, we see adequate means employed for the accomplishment of an important end.

The sap of most plants, when collected in the spring, appears to the sight and taste little else than water; but it soon undergoes fermentation and putrefaction. The perspiration from the leaves is, for the most part, a clear, watery liquor, like the sap, and subject to similar chemical changes. The sap increases in density in ascending the tree towards the leaves. Mr. Knight thinks this is owing to its being mixed with a quantity of matter previously deposited in the alburnum for that purpose, and ready to be assimilated to the different vegetable organs. According to him, plants are employed in the latter part of the summer in preparing food for the expanding of the buds and blossoms in the succeeding spring. This food, when prepared, is deposited in the alburnum. There it is lodged during the winter, and next spring, mixing with the ascending sap, it affords nourishment to the buds and leaves.

In plants, the leaves perform the office both of the stomach and lungs in animals. While they receive the sap from the roots and sap-vessels, they imbibe nourishment from the circumambient air. While absorption is carried on by the extremities of the roots, the leaves seem to concur in the same process, chiefly by their under surfaces; and they transpire by their upper surfaces. Some plants imbibe moisture with the greatest facility, and transpire very sparingly: thus they are fitted for inhabiting sunny rocks and sandy deserts. The sap, in its passage through the leaves and bark, becomes quite a new fluid, possessing the peculiar flavor and qualities of the plant; and not only yielding woody matter for the increase of the vegetable body, but furnishing various secreted substances, more or less numerous, and different among themselves.

We have already observed the great principle of assimilation in the human body; that mysterious process by which the aliment is converted into blood, and flesh, and cartilage, and bones. We meet with the same mystery in the vegetable kingdom. Plants secrete sugar, gums, and various resinous substances, from the uniform juices of the earth, or perhaps from mere water and air. We observe, however, this difference in these two great departments of organized nature; sentient beings feed only, or chiefly, on what is, or has been, organized matter, either of a vegetable or animal kind; but plants have a power of drawing nourishment from inorganic matter, mere earths, salts, or airs (substances incapable of serving as food for animals), though not from these exclusively. Thus vegetables are the great link between inorganic matter and animal bodies, preparing the former for becoming a constituent part of the latter; and, as vegetables take in their food in the shape of sap, it appears that the transition from inorganic to organized matter is through the medium of fluidity.

From the same soil different plants secrete each their peculiar fluids; but how sweet and nutritious herbage should grow among the acrid crowfoot and aconite; how the leaf of the vine and sorrel should digest a wholesome acid, and that of spurge or manchineel a most virulent poison, is something which we can neither understand nor explain. For this, chemical principles will not account. In the living laboratories of nature, wonders are performed, immeasurably surpassing all the processes of art, and plainly indicating the existence and operation of an Intelligent Cause, powerful, wise, and good.

Of the peculiar secretions of plants we can form no certain opinion from the mere configuration of their parts. If these secretions depend on internal organization, the secrets of that organization have hitherto eluded investigation. At times, under the same external appearance, or at least such as even men of science cannot easily distinguish, they conceal very different qualities. The sweet and bitter orange-trees have the same appearance. Between the sweet and bitter jatropha there is a great resemblance; although the root of the one may be eaten with safety, while that of the other is an active poison. Here, as in every other department of nature, we meet with an order of things calculated to awaken the attention, exercise the vigilance, and solicit the intellectual energies of man. The brutes judge by their senses, and their senses do not deceive them. Man is endued with higher powers, and these must be brought into action; although his senses, if unperverted, will not mislead him.

As every vegetable is capable of bearing seed, so for the dispersion of seeds there is a wonderful provision. Some are widely sown by birds and other animals: others, as those of the thistle, are fitted with a wing or a sail, and wafted on the wind; and some are shot from their places by the elastic spring of a pod, in which they have been ripened. Many seeds, when kept dry or deeply buried in the earth, retain the power of germination for an unlimited period. If the ground in old botanic gardens be digged deeper than ordinary, it not unfrequently happens that species which have been long lost are recovered, by the seeds which have been buried in the earth being brought into a proper situation for germination.

Seeds and plants possess something analogous to the instincts of animals, for the preservation of the individual and the continuation of the kind. In what position soever a seed be deposited in the earth, the radicle always pushes downwards in quest of nourishment, and to fix the plant into the ground; and the plumula, with unvarying steadiness, rises upwards. We may attempt to account for this, by saying that the radicle is stimulated by moisture, and the plumula by air, and that each elongates itself where it is most excited. Be this as it may, we see a constitution of things adequate to the accomplishment of important ends. A constitution of this kind is wise, and must have proceeded from a wise author; and if it produce beneficial effects, its author must be good.

The roots of trees, it is well known, alter their direction in quest of nourishment; and the leaves, which perform such an essential part in vegetation, if disturbed, soon adjust themselves, and turn their upper surfaces to the light. If a leaf be smeared over, so that its communication with the atmosphere is cut off, it dies, like an animal when respiration is stopped. Some animals are adapted to particular climates and circumstances. The same is the case with vegetables; in some of which, as the *tillandsia*, a very curious provision is made to fit them to peculiar circumstances.* Some have tubular leaves, which receive the rain like a funnel; and some are so formed as to prevent evaporation from their cisterns.

Wisdom is strikingly displayed in the wonderful structure of plants, and in the provision made for the preservation of the individual and the continuation of the kind.† Wisdom and goodness likewise appear in the admirable relation between the animal and vegetable kingdoms. Vegetables might

* The tillandsia is a parasitical plant (a kind of mistletoe) which grows on the tops of trees in the deserts of America. It has its leaves turned at the base into the shape of a pitcher, with the extremity expanded: in these, rain is collected.

† As an instance of wisdom evinced in the provision made for the continuation of the species of plants, the student is referred to the *vallisneria*, illustrated by Pl. XXIV.

exist without animals, but many animals could not exist without vegetables; and of vegetables there is a variety to suit the peculiar taste of every creature, and an abundance to supply the wants of them all. Those that are the most generally relished, and consequently the most useful, are the most common; and there is reason to conclude that there is no vegetable on the earth but what contributes, or may contribute, to the subsistence, or comfort, and accommodation of man, or of the inferior animals. The earth produces nothing that is useless. Vegetables that are unpalatable to one class of animals are grateful to the taste of another; and the more that the leaves of perennial grasses are eaten, the more do they creep by the roots and send forth offsets. Trees furnish a lodging to various tribes of animals; and, besides yielding food, are made subservient to many useful purposes by the human race.

CHAPTER IX.

THE ATMOSPHERE.

Having glanced at this earth and its inhabitants, let us now for a little turn our attention to the thin, elastic, and transparent fluid which constitutes the envelope of our globe.

Had the earth been formed by a casual concurrence of atoms, or by any undesigning cause, the probability is, that it would have remained forever a naked mass, like the lonely, blighted oak on the barren desert. But we see it a beautiful globe, adorned by verdure, enriched with plenty, and exhilarated by life and enjoyment, and all these depending on the atmosphere with which it is surrounded, as an essential condition. Atmospheric air consists in bulk of twenty-one parts in the hundred of what is at present called *oxygen gas;* about seventy-nine of *azotic* or *nitrogen gas;* and a small, but somewhat variable, portion of carbonic acid gas. The two last of these, namely, the azotic and carbonic acid gases, can support neither life nor flame. If an animal be immersed into either of them, it almost instantly dies. Oxygen gas alone will support the vital functions for some time; but animals confined in it expire long before the whole of it is consumed. The proportions of these gases in atmospheric air are the best fitted for supporting both animal and vegetable life. An excess of any of them is injurious or fatal.

But while the proportions of the gases in atmospheric air are best adapted to the economy of the animal system, that system is so constituted, as to be capable of bearing considerable variations in the composition of the air, without immediate injury to the powers of life. Are not design and skilful contrivance manifested in the constitution of atmospheric air? The proportions of its constituent parts are nearly the same in all places and at all heights. The azotic is lighter than the oxygen gas, and this last has less specific gravity than carbonic acid gas; yet these two last are found in about the same proportions at the greatest heights to which the genius and intrepidity of man have ascended, as at the level of the sea. What astonishing contrivance raises the oxygen and carbonic acid gases to every height in the atmosphere—to the summit of Chimborazo, and to the loftiest region visited by the balloon? Is there no design, no skilful contrivance in the wonderful adjustment of the affinities and specific gravities of these different aeriform fluids? Did Priestley,* Scheele,† and Lavoisier,‡ act without design, contrivance, and skill, in the processes by which they decomposed atmospheric air, and discovered its component parts? No one thinks so. And shall any person be so absurd as to deny design, wisdom, and goodness, in the adjustment of those proportions, and in fitting them for the benevolent purpose of supporting life?

There is no physical necessity for the atmosphere. The earth might have existed without any such invisible robe flowing around it. The moon is not provided with an atmosphere; at least not with one so dense as ours. Might not the earth have been constituted in the same manner? But, if it had been so, it could not have been a place of residence for its present inhabitants. Without the atmosphere neither animals nor vegetables could have existed: withdraw even its oxygenous part, constituting only about a fifth of the bulk of the whole, and every organized being dies. If any person, then, deny design and wisdom in the formation and constitution of the atmosphere, we are entitled to call upon him to show the physical necessity of an atmosphere, yea, of an atmosphere constituted as ours is. It is undeniably adapted to

* An indefatigable student of philosophy, born in Yorkshire, England, and died in Northumberland, Pennsylvania, 1804, æt. 71. His writings are very numerous, embracing subjects of natural philosophy, chemistry, theology, mental philosophy, ethics, and philology.

† An eminent Swedish chemist, born at Stralsund, and died, 1786. His most valuable treatises are those on air and fire.

‡ A celebrated chemist of Paris, and author of many valuable works on his favorite science. To the amplest resources of mind he added all the amiable qualities of the heart. He was guillotined, 1794, to gratify the malice of the minions of Robespierre, æt. 51.

the other parts of the system, and is an essential part of one beautiful whole. What a mighty difference is there between the earth and the atmosphere! The one is a dense, opaque, and incompressible body; the other a thin, transparent, invisible, and highly-elastic substance. Yet between the two there is an obvious relation. Dissimilar as they are in themselves, they harmoniously combine for the accomplishment of the most beneficial purposes. Respiration, the propagation of sounds, the conveyance of odors, combustion, the support of vapors, the refraction and reflection of the rays of light, all depend on the atmosphere.

The atmosphere cannot form a single living creature: no being on earth formed it; yet without it no animal could exist. Without the lungs man could not live; but without the atmosphere the lungs were a useless organ. The lungs did not apportion the constituent parts of the atmosphere; yet no other proportions are so well suited for supporting animal life. The ear did not form the atmosphere, nor did the atmosphere create the ear: they exist independently on each other; yet there is an admirable relation between them. Without the atmosphere, the ear had been bestowed in vain. Decisive experiments prove that air is the medium by which sound is propagated. To it we are indebted for the pleasures of speech and the charms of music. Without it, the organs of speech and of hearing would have been useless; but the introduction of this element gives interest and utility to the tongue and to the ear.*

The atmosphere conveys odors; and, in this way, is a source of pleasure, and a monitor against danger. There is an obvious relation between the atmosphere and the wings of birds. He who formed the wing of the eagle evidently fitted the bird for rising buoyant on the air. Without the air, wings would have been a cumbrous appendage; but, according to the present constitution of things, wings are of great importance to the bird, and are suited to all its habits. Even the ostrich, though it does not fly, is impelled in its rapid career by the action of its wings.

Air is necessary to fire. Whatever theory of combustion we adopt, we must admit the atmosphere is requisite to the process. The air supports vapor, which is exhaled from the

* The air, by the conveyance of sounds, furnishes us with the means of measuring distances. In any terrestrial distance, the passage of light may be considered as instantaneous; but sound travels at the rate of about 1142 feet in a second. Hence we may measure the distance of the cloud, from which the lightning and the peal of thunder proceed.

earth and from the ocean by the heat of the sun. Evaporation is a great process of nature, which is continually going on, and is essential to the system. The quantity of water raised into the air in this manner, is much greater than, at first sight, we would imagine. Dr. Watson,* by inverting a glass vessel on the ground in the time of a considerable drought, found that, even then, about 1600 gallons of water were evaporated from an acre in 24 hours. On repeating the experiment, after a thunder-shower, he found that an acre yielded about 1900 gallons in 12 hours.

This process is carried on not only from the ground, but also from the leaves of trees and plants, as well as from the surface of rivers and lakes, and the ocean. A great part of the moisture exhaled during the day descends in dew during the night, and is absorbed by the vegetables which had before given it out. In this way the earth is not so soon desiccated, even for a little way below the surface, as we might be apt to imagine from the quantity of water raised by evaporation. If all the moisture, exhaled during the time of a long drought, left the earth, not to return to it for the space of several weeks or months, all plants which do not strike their roots very deeply into the ground must of necessity be destroyed. But nothing of this kind takes place, excepting with the most tender grass, when on elevated situations, and much exposed to the rays of the sun.

The water that is carried into the air by evaporation, returns again to the earth in dew and fogs, rain, hail, or snow, according to the climate and the season of the year. It does not descend in impetuous spouts, nor yet in large sheets. Had it done so, instead of being the messenger of plenty and of joy, it would have been the author of desolation and mourning, mangling the vegetable kingdom, overthrowing the habitations of man, and destroying himself. Can we contemplate the invisible drops of dew, the drizzling shower, reviving and refreshing the thirsty plants, and the copious rain moistening the earth, and not be filled with grateful admiration of the wisdom and goodness manifested in that constitution of things by which dews and rains descend as from a colander? The phenomena of rain we are unable fully to explain; but we see a beneficial end accomplished; and although we have not yet discovered all the steps of the process, or the precise op-

* The distinguished author of the "Apology for the Bible," in answer to Paine's "Age of Reason." He was professor of chemistry, and afterwards of divinity, in Trinity College, Cambridge. He was made Bishop of Llandaff in 1782, and died 1816, æt. 79.

eration of the different agents employed, we have sufficient reason to believe that the constitution of this meteor was framed by a wise and beneficent First Cause.

The atmosphere also serves to refract the light of the sun, and to reflect it in all directions. To the refraction of the rays of light by the atmosphere, we are indebted for the morning and evening twilight. Without this refraction, thick darkness would prevail in the morning till the sun were above the horizon; and, in the evening, would immediately follow the disappearance of this orb. At the equator the twilight is short, because there the earth moves with great rapidity in its diurnal rotation, and, consequently, its rotundity soon intervenes. The refraction of light is very serviceable to those who live in polar regions. By means of it their long night is abridged, and they see the returning light sooner than otherwise they could have done. The sun was visible to some Dutch navigators, who wintered in Nova Zembla in 1682, sixteen days sooner than he could have been seen if there had been no atmosphere to refract the rays of light.

If the refractive power of the atmosphere be beneficial to the inhabitants of the earth, its reflection of light is much more so. Without atmospheric reflection we could see no light but when our eye was turned to the sun. Solid bodies, indeed, that reflected the rays, would glitter: they would glitter, however, in the midst of darkness. But from the reflection of the solar rays, in all directions, by means of the air, the hemisphere is as completely illuminated as if the sun were commensurate with it, and were fitted up over our globe like a semispherical cap. Here, in the simplicity of the means, we may recognize the wisdom of the Agent. Every aeriform fluid would not answer all the purposes of the atmosphere. Some of them are too rare for supporting vapor; most of them are unfit for the purposes of respiration. But the atmosphere is admirably adapted to the globe which it surrounds: it serves many different purposes, and is essential to a vast system of life and enjoyment.

It is a well-known fact, that atmospheric air is deteriorated, and rendered unfit for the support of life, by combustion, the germination of seeds, the vegetation of plants, and the respiration of animals. Were this deterioration to go on continually increasing, without counteraction or compensation, the atmosphere would daily become more unfit for the purposes of respiration, till, at length, the whole mass of air would become contaminated, and life be extinguished. But it exists at this moment in as pure a state as it ever did. It is as fit as ever for supporting both animal and vegetable life. Hence it is evident that a great restorative process is continually going on, by means of which the purity of the general body of the atmosphere is preserved. This process, which is an exact counterpoise to the causes of contamination, the present state of our knowledge does not enable us fully to explain.

Dr. Priestley observed that, in vegetation, leaves have the property of absorbing carbonic acid gas from the atmosphere; and hence he concluded that vegetation was a great restorer of the purity of the air contaminated by respiration. This doctrine has been controverted; but, after much investigation, it appears, to a certain extent at least, to be true. In germination, indeed, seeds absorb oxygen, and give out carbonic acid. A similar process goes on in vegetation when plants are in the shade, or in the dark; but when they are exposed to the action of the solar beam, the process is different. Then, by the joint agency of the plant and of light, the carbonic acid is decomposed and oxygen gas developed. In the shade, or in the dark, plants convert oxygen into carbonic acid; and, when confined in a given quantity of air, this conversion goes on till all the oxygen disappears. But under the action of the solar rays, in conjunction with the leaves of the plant, carbonic acid is decomposed, and oxygen gas is formed. This conversion and re-conversion of gases go on simultaneously; in what proportion has not yet been determined.

Thus, if plants deteriorate atmospheric air, they likewise contribute to its restoration to purity; but how far this contribution extends, on the great scale of nature, cannot be easily ascertained. By experiment and careful observation, we may discover the processes of nature; but from the minute scale on which our experiments are performed, in many cases, it is not easy, from their results, to make any exact calculations respecting the processes in the vast system of the world. In the case under consideration, I know of no experiments which will enable us to make even an approximation to the degree in which vegetation purifies the atmosphere. In all probability, its influence in restoring is at least as great as in contaminating the air; perhaps much greater. We may still say that, in this respect, there is a continual circulation of benefit between the animal and vegetable kingdoms.*

* It has been said, that the oxygen produced by plants arises solely from the decomposition of the carbonic acid, and that this production of oxygen depends altogether on the chemical effect of light on the leaf, and is unconnected with the functions of vegetation. Be this as it may, it is certain that the conversion of gases accompanies the process of vegetation.

Water lends its aid in purifying contaminated air. It absorbs carbonic acid when brought into contact with it; and the rapidity of the absorption is much increased by agitation. Now, water and air are brought into a state of contact by the exhalation of vapor, the descent of dew and rain, and the action of winds. The very processes which are necessary in order to vegetation and life, contain in them the principles by which the purity of the atmosphere is preserved. Although we were wholly unable to discover any part of the process by which contaminated air is restored to purity, still the argument from the fact would remain unanswerable. That a great process of restoration is continually going on, and that the air is preserved in a state of purity, cannot be denied. Our ignorance of the means merely proves the narrowness of our capacity, or the imperfection of our science.

Wind is air in motion, or a current of air, and is occasioned chiefly by the disturbance of the equilibrium of the atmosphere, by the unequal distribution of heat. The winds serve some important purposes in nature, and are great agents in carrying on the economy of that system of which they form a part. Confined and motionless air soon becomes unfavorable to respiration; but the winds agitate the atmosphere, and maintain its salubrity, purifying what has been contaminated, and removing noxious emanations. They transfer from place to place the clouds destined to scatter over the face of the earth those rains which moisten and fertilize it. They are the vehicles of many seeds, which, being provided with wings or down, are wafted to all parts in autumn, and keep up a constant circulation of vegetable riches between different soils. They modify the temperature of the air, bringing the heat of the equator towards the poles, and carrying the polar cold towards the torrid zone. They also maintain an intercommunity of temperature between the sea and land. In tropical climates, the sea-breeze bears in its bosom a refreshing coolness, and fans the traveller panting under a vertical sun: the wind blowing over the ocean serves to mitigate the cold of high latitudes. Like many other parts of nature, the winds solicit the ingenuity, and aid the industry of man. Without them navigation must have been almost unknown, and the commerce of distant nations altogether impracticable.

CHAPTER X.

LIGHT.

LIGHT is a most astonishing substance; and between it and the eye there is an obvious relation. Without light the eye had been a useless organ; and without the eye light had been to sentient beings, in some respects, an unprofitable emanation. But, by the genial operation of light, the eye beholds creation in all its magnificence, beauty, and variety. Light did not create the eye, for it was formed in darkness; nor did the eye give existence to light; yet there is such an adaptation of the one to the other, as compels us, by the very constitution of our nature, to believe that it is the result of design. And the designing cause must be wise and good; for the means are happily fitted to the end, and the end is beneficial. The air is the vehicle of speech, and by means of the ear enables us to carry on an intercourse of thought with our fellow-men; but how greatly is this intercourse extended, diversified and improved by light and the eye!

It may here be assumed as a fact, that light is emitted from the luminous body, and moves in straight lines. Its prodigious velocity cannot fail to engage our attention. It travels about twelve millions of miles in a minute. The discovery of this fact is a noble proof of the exalted powers of the human mind; and yet it depends on circumstances so intelligible that every person may understand the matter. The eclipses of Jupiter's moons can be exactly calculated; and Roemer,* a Danish astronomer, observed that these eclipses are seen sixteen minutes sooner when the earth is in that part of its orbit which is nearest Jupiter, than when it is farthest from him. This shows that light takes sixteen minutes to travel through a space equal to the diameter of the earth's orbit, and, consequently, eight minutes to pass from the sun to the earth—a distance which, with Dr. Maskelyne, we may estimate at ninety-five millions of miles. This wonderful fact was afterwards confirmed by Bradley's† curious discovery of the aberration of the fixed stars.

Even the initial velocity of a cannon ball seldom reaches

* Professor of astronomy at Copenhagen. His observations on light were noticed and applauded by Newton. He left no literary work behind him. He died, 1710.

† Professor of astronomy at Oxford, and afterwards astronomer royal at Greenwich. He discovered the laws of the aberrations of the fixed stars in consequence of the motion of light, and also of the rotation of the earth's axis.

2000 feet in a second; but in the same time light moves about 200,000 miles; consequently with upwards of 500,000 times the greatest initial velocity of a cannon ball. Unless the particles of light were inconceivably minute, they would dash in pieces every thing that came in their way. But such is their extreme exility, that, notwithstanding their amazing velocity, they strike even the delicate pupil of the eye without injuring it. The person who can reflect on this without a strong conviction and a grateful impression of an Intelligent Cause, and without admiration of the wisdom and goodness of that Cause, must have a mind inaccessible to moral evidence, and destitute of the noblest feelings of humanity. The beneficial effects of light are too extensive to be overlooked, and too obvious to be denied. They force themselves on the notice of the careless, and command the assent of the skeptic.

The particles of light seem strongly to repel each other, and are never found cohering together so as to form masses of any sensible magnitude. There are several differently-colored rays in the solar beam, which can be separated by the prism; and the color of bodies depends on their affinity for particular rays, and their want of affinity for others. Thus, to light are we indebted, not only for seeing nature around us, but for all that charming variety of colors, all those delicate tints which diversify and adorn the vegetable kingdom. The upper surface of leaves is of the most pleasing green, and the exquisite tints of flowers are inimitably beautiful. The most skilful painter cannot so mingle and temper his colors as to rival their native hues.

Light is the cause of that agreeable variety which we meet with in the taste and odor of plants, and is the main source of their combustibility. It is not in the vegetable kingdom only that the influence of light is felt; it acts also on animals, and considerably affects their color. The bellies of fish, being always turned from the light, are white; but those parts of their bodies which are exposed to it exhibit various colors. Tropical birds are more brightly colored than those of higher latitudes; and the parts of the feathers have more or less variety of color, as they are more or less exposed to the action of light. The upper part of the feathers of the wings have more brilliancy than those of the breast. A similar observation applies to the hairs of quadrupeds; and light and heat seem to be powerful agents in producing that variety of color which is observable in the human race.

Whether light and caloric, or the matter of heat, be the same substance under different modifications or combinations, I shall not inquire. Suffice it to say, that they are found together in the solar beam. Heat is the cause of fluidity, and is essential to the existence of our earth in its present form. The great law of attraction pervades the universe, so far as our observation extends; and had it alone acted, all must have been one solid mass. In order to constitute a system such as ours, it was necessary to introduce a principle of repulsion, which, in a proper degree, should counteract the law of attraction. This principle of repulsion we find in heat; by the action of which solids are converted into fluids, and fluids into vapor. Here we may remark the wisdom displayed in so nicely balancing the principles of attraction and repulsion against each other. Had there been any considerable difference in either of these from what now obtains, the world would not have existed in its present form, nor yielded subsistence to its present inhabitants. Had the power of attraction and cohesion been much greater, and the degree of heat the same as at present, we should have been in want of fluidity: had the quantity of heat been much greater, and attraction, as well as the pressure of the atmosphere, the same as at present, all our fluids would have been converted into vapor. But these powers are exactly adjusted to one another and to the rest of the system.

Heat is necessary both to vegetable and animal life; and it appears a decided evidence of the wisdom and goodness of the Supreme Being, that the living functions, both of plants and animals, disengage the portion of heat necessary for their well-being: this they seem to accomplish by converting oxygen into carbonic acid gas, in which process a quantity of heat is evolved.

CHAPTER XI.

ASTRONOMY.

Having taken a cursory view of the terraqueous globe, with its productions and inhabitants; of the transparent and elastic fluid with which it is invested, and of light and heat which beautify and enrich it, let us now, for a little, quit the earth, and contemplate the splendid orbs that bespangle the vault of heaven. At an early period the Chaldean shepherd, watching his flocks under an unclouded sky on the extensive plains washed by the Euphrates and the Tigris, attentively observed the stars in their silent revolutions. He marked the brilliancy of Sirius, and the majesty of Orion. With a vigilant eye, he followed the Twins and Arcturus in their course, and learned the unvarying relative position of these twinkling ornaments of the sky. But the planetary motions perplexed him by their apparent intricacy and irregularity, and defied his sagacity to unravel their seeming confusion.

The Phenician mariner turned his eye to those stars which appear to describe very small circles, or with stately majesty to remain motionless in the firmament. Some of the stars of the Dragon, or of the Great Bear, it is likely, were his guides in creeping timidly along the shores of the Mediterranean, or of the Arabian Gulf. The star Alruccabah, in the tail of the Little Bear, which, by the precession of the equinoxes, is now near the immovable point of the heavens, probably did not attract much of his attention. These Chaldean shepherds and Phenician navigators, although they could impress, in some measure, the stars into their service, had but a very limited and partial knowledge of astronomy. There is a vast distance between their rude observations and the noble discoveries of Newton and La Place. For, with the exception of the comets, the solar system is now well understood; and the motions of all the great bodies connected with it are ascertained with the utmost precision, and can be explained by the laws or facts of projection and gravitation.

Astronomy bears a strong testimony to the existence of God, and furnishes clear proofs of his mighty power, consummate wisdom, and great goodness. "My opinion of astronomy has always been," says Dr. Paley, "that it is not the best medium through which to prove the agency of an intelligent Creator." The opinion is not without some foundation. But I must acknowledge, that no part of Dr. Paley's masterly work on Natural Theology made a deeper impression on my mind than the chapter on astronomy. We are not, indeed, acquainted with the inhabitants of the planetary bodies, and consequently cannot trace minute contrivance and mechanical adaptation in their organization, or in the provision that is made for their subsistence, accommodation, and comfort. We can reason only on the forms, arrangements, and motions of the planets. But even within this range we meet with decisive proofs of design, power, wisdom, and goodness.

1. The *forms* of the heavenly bodies are all spheroidal,

whatever be the diameter of the sphere. This holds from the sun, the largest, to Pallas, the least, perhaps, of the bodies in our system. The spheroidal figure is best fitted for the motion of the planets, whether in their orbits or on their axes. It is best adapted for the equal diffusion of light; and, judging from the inhabitants of our earth, it is also most commodious for furnishing a residence to living creatures.

Now, was there any physical necessity for the spheroidal figure? I may, perhaps, be told that it results from the motions. Passing over, at present, the difficulty of accounting for the motions without an Intelligent Cause, I should like to know what is the evidence that the planets were not spheres at their first movement, as well as at present. In my apprehension, I have as good a right to allege that the sphericity was prior to the motion, as another has to say that the motion generated the sphericity. Supposing, however, that the planets were not spheres originally, we may inquire how they moved before they assumed the spheroidal form. What was their original figure? Supposing them to have been cubes, parallelograms, or very irregular figures, how did they revolve till they acquired their present shape? Must not the axis of rotation have been perpetually shifting? And would not this shifting have prevented them from acquiring their present figure? Besides, if our earth, for instance, was as dense at first as it is now, its rotation on its axis would have had very little influence on its figure. The solid parts of the earth do not appear to be affected by its rotation.

But we may be told, perhaps, that the matter of the planets was struck off from the body of the sun in a state of fusion, and thus assumed the globular form by rotation. This, however, is a purely hypothetical assumption countenanced by no one known fact in nature. We do not know that the sun himself is an ignited body. We do not know that any great masses, in a state of ignition and fusion, exist in the universe. We have no evidence that our earth, or any other planet, is gradually cooling. To assume principles which receive no countenance from the existing phenomena of nature, may do with the dreaming theorist who surrenders himself to the guidance of a loose imagination; but such a practice can never be admitted into the school of sound philosophy. We may add that it is unreasonable to expect that every wild hypothesis devised by a fertile fancy should be seriously refuted. In order to entitle a theory to attention, it must be countenanced by known facts. Without this, it is, at best, but an amusing fiction.

According to La Place,* a body with the same time of rotation, may put on two very different forms, which will preserve their equilibrium: the one of them is very near a sphere; the other, very far from it. In the case of our earth, supposing it to have been originally a homogeneous body, the parts of which would all freely yield to the centrifugal force, one of the forms would have the ratio of the polar to the equatorial diameter as 229 to 230, which is near the ratio that actually obtains; and the other as 1 to 680.† In all the planets, we find that form which is nearest to the sphere, and which, in point of utility and convenience, is unquestionably the more advantageous of the two; for the other form is nearly a flat circular body, having a convex edge. If it be alleged that the spheroidal form results from gravitation, we may ask such questions as the following:—Will gravitation account for all the phenomena? Is gravitation a necessary or a contingent fact? Is it essential to matter? That it is essential to matter cannot be proved. And if it be not essential to matter, yea, if the ratio in which it is observed to act be not essential to matter, then every advantage resulting from gravitation, and from the particular law which it observes, may be reasonably attributed to design.

There is one phenomenon in the planetary figures, for which neither rotation, nor gravitation, nor both of them, will in any degree account; I refer to the ring or rings of Saturn. Although rotation and gravitation may preserve these rings in their places, they will not account for their formation. Galileo was the first who observed something uncommon in the shape of Saturn; and the ring was more fully discovered by Huygens about forty years afterwards. It is now found that this planet is encompassed with two thin, flat, concentric rings, lying edgewise towards the planet, and at some distance from it. The plane of these rings passes through Saturn's equator. The rings revolve in their own plane, in about ten hours and a half; and, not being of a regular figure, their centre of gravity is at a small distance from the centre of Saturn. The centre of gravity being carried about Saturn

* A distinguished mathematician and astronomer, whose numerous works have greatly benefited the science of astronomy, particularly his "Theory respecting the Movements of the Planets." His "Celestial Mechanism" has been translated, with a commentary, by Dr. Bowditch of Boston (1830, 4to.).

† See Vince's Confutation of Atheism, p. 66. The figure of the earth is not yet precisely ascertained. It appears certain that the equatorial diameter somewhat exceeds the polar axis. The difference between the polar and equatorial diameters seems to lie between 300 to 301, and 340 to 341. The French astronomers have made it $\frac{1}{334}$ (Montucla, vol. iv. p. 170); others, $\frac{1}{312}$ (Playfair)

by the rotation of the rings, gives them a centrifugal force, which is combined with their gravitation to the planet; and they are retained by these two forces, in the same manner as a planet is retained in its orbit.

The formation of these rings must have been either instantaneous or gradual. But how will gravitation, or even gravitation and rotation combined, account for their formation in either of these ways? Gravitation could never have produced bodies of such a figure. It could not form them instantaneously: there is no known property of gravity capable of producing such an effect. Neither could it do so gradually; for what was to support them, in an unfinished state, during a gradual formation? I see no way of accounting for the figure of those rings, by matter, gravitation, and motion. And if their figure cannot in this way be accounted for, the question becomes still more complicated and perplexing, when we attend to their motion. To produce the rotation, the force applied must act in the plane of the rings; but a single force acting thus would have disturbed their position, and carried them up to the planet. There must have been impressed equal and opposite forces, at equal distances on each side of the centre, in order to give them rotation without altering their position. The figure of the rings is not regular: La Place has shown that if it had been regular, the rings could not have preserved their position, but must have been disturbed by the slightest force, such as the attraction of a comet or satellite, and fallen upon the planet; and that it is owing to those irregularities that they are supported in their proper situations. In the other bodies of the system, regularity of figure tends to insure uniformity of motion, and there regularity prevails. But here irregularity is found to exist, and it was needful in order to permanency. The rings are of a form which could not have arisen from the gravitation of their parts. They are concentric, placed exactly in the same plane, and in the plane of Saturn's equator. Their progressive velocity is exactly adjusted to the velocity of Saturn in his orbit, both in respect of quantity and direction; and they have a certain degree of inequality in their figures, which, with a corresponding period of revolution about the planet, is the means of securing them in their position. Here, then, we see such a complication of adjustments, as must irresistibly impress us with the belief of an Intelligent and Wise Cause.

II. Design appears in the *arrangement* of the heavenly bodies.

The sun is the central body of our system. Of the physical constitution of that luminary we cannot speak with certainty. But, whether we consider it as an ignited body, or as an opaque orb, surrounded, at a distance from its surface, with clouds emitting luminous and calorific rays, the fact is certain, that it is the great fountain of light and heat to the system. Design, wisdom, and goodness, are obvious in this single fact. Had the universe been the result of any undesigning cause, what probability is there that there would have been any luminous body in the system? At present, besides comets, we know of eleven primary and eighteen secondary planets. These are all opaque orbs. How, then, but by the admission of an Intelligent Creator, shall we account for one, and only one, luminous body in our group of worlds? But supposing one luminous body to have somehow appeared among the opaque planets, how shall we account for its being a large body, yea, larger than any, or all of the rest? What is there in light and caloric to attach them to the largest body exclusively, or to make the body to which they are attached assume a central position? If gravitation be alleged as the cause, we answer that it will not account for the phenomena. How, on this supposition, are light and heat emitted?

If there had been no sun, it is obvious that the present order of things could not have existed. Without light and heat there could be neither vegetable nor animal life. The light and heat of the sun cannot create a single seed, but by means of one previously existing: they cannot form any animal without the intervention of a seminal principle from a parent animal. The sun, then, has not created any thing here; and nothing here created the sun: yet between the sun and the earth there is an obvious relation. For if you remove the sun, you at the same time extinguish vegetable and animal life on the earth. Have not wisdom and goodness, then, provided this essential condition of animal and vegetable existence?

If the luminous body had been small compared with the other orbs in the system, like Juno or Pallas, or even like our earth; if it had not been a central, but a revolving body round the centre, then light and heat could not have been in the same quantity, nor could they have been so equably distributed as they presently are. But the sun is a vast globe, and stationary, or nearly so, in the centre, diffusing light and heat, and life and joy, over all his attendant worlds. It is needless to enter into any calculation of the probabilities, that in a system of thirty bodies (leaving the comets out of the question) grouped together by the law of gravitation, one, and one only, should be luminous, and that *that* one should be largest, and in the centre. To me it appears that, on the very face of the thing, there is a plain evidence of design; and not of design only, but of wisdom and goodness also.

The very large bodies, Jupiter, Saturn, and Uranus, are placed at a great distance from the centre. Had they been next the sun, their joint attractions would have greatly disturbed the less and more distant planets in their revolutions. But, travelling in orbits at such an immense distance from the centre, they attract the sun and the inferior planets almost equally; which, in point of perturbation, is nearly the same as if they attracted neither. This results from the law which gravitation observes, decreasing in the inverse ratio of the squares of the distances.

The distances at which the planets are placed from each other are an indication of wisdom. Had not the bulk and distance of the circumvolving bodies been wisely arranged, the attraction of one would have drawn another from its orbit. They would have met together in terrible and destructive collision: confusion and ruin would have ensued. But so wisely are the bulks, velocities, and distances of the planetary orbs adjusted to the established law of gravitation, that, though they act on each other, they do not act so powerfully as to derange the system. The perturbations are partial, limited, and periodical. A great compensating principle pervades the universe, and keeps the disturbing powers within harmless limits. The vast extent of the system gives room for the bodies to move, without endangering its permanency by their mutual attractions: it likewise prevents those great tides which would have happened, if the large planets had moved near each other.

In all the planets, so far as we know, the axis of rotation forms a greater or less angle with the plane of the orbit. For this there is no physical necessity. But in our earth, where we have the best opportunity of observing and judging, it is productive of beneficial effects. To it we owe the variety of seasons. Had the axis of rotation been parallel to the plane of the orbit, each hemisphere, in its turn, would have been long in darkness. If the axis had been perpendicular to the plane of the orbit, light would, indeed, have been diffused from pole to pole; but the equatorial regions would have been scorched with perpetual and unvarying heat, whilst in the higher latitudes the influence of the sun would have been too faintly felt to bring vegetation to maturity. But, by the inclination of the axis, light and heat are more beneficially diffused over the globe.

Under the head of arrangement, we may take notice of the provision of moons.

Mercury and Venus, moving in orbits at no great distance from the fountain of light, are provided with none of those attendants. One accompanies our earth; and, as its orbit forms but a small angle with the ecliptic, it is very beneficial to its primary. The time of the moon's revolution round the earth is just equal to the time of her rotation about her own axis. The same holds of all the satellites of Jupiter; and of one, at least, of Saturn. From the uniformity which prevails in the other parts of the system, it is likely that the same is the case with all the secondaries, although it has not yet been ascertained by observation. In this way, the secondary always keeps the same face towards the primary. Now, in this constitution of things, we may perceive plain indications of design, wisdom, and goodness. When we consider the number of nice adjustments that are necessary in order to make the secondary always keep the same face towards the primary, and attend to the number of bodies in which this constitution obtains, it is impossible to attribute it to any thing but design. The end is good; for had the constitution of those bodies been different, the primary would have occasioned injurious or destructive tides on the secondary; but by keeping the same face of the moon always towards the earth, this evil is avoided. Whatever may be the elevation of the waters upon the moon, it always remains the same, or nearly so.

Mars has no satellite. The four newly-discovered planets, Juno, Vesta, Ceres, and Pallas, are very small bodies, and unable to carry moons along with them. But Jupiter, a vast globe, moving in an orbit about 490 millions of miles distant from the sun, is provided with four satellites, placed at different distances from his centre, and performing their revolutions in different periods. Saturn, revolving in an orbit twice as distant from the sun as that of Jupiter, besides the apparatus of his rings, has no less than seven moons attending him. Uranus, about 1800 millions of miles distant from the sun, is known to have at least six moons.

Light decreases as the squares of the distances increase; consequently in those distant regions the solar rays must be very sparse. But the remote planets are amply provided with satellites to reflect the light; and, to me, the provision of moons in the system appears to afford no slight evidence of design. The most distant planets are capable, by their mass, of supporting moons, and they are provided with them. Perhaps, in the other planets, these satellites serve other beneficial purposes besides that of illumination, as the moon does to our earth. Distant as they are, they are of advantage even to us: the moons of Jupiter assist us in determining the longitude.

III. The *motions* of the planets afford plain proofs of design, whether we attend to their revolutions in their orbits, or to their rotation on their axes.

The adjustment of the centripetal and centrifugal forces, so as exactly to balance each other, is a wonderful fact in nature. The planets all move in ellipses, not greatly removed from circles, having the sun in one of the foci. The general law or fact, in nature, so far as we can observe, is, that all bodies attract each other in the direct ratio of their masses, and in the inverse ratio of the squares of the distances. It has, indeed, been asserted that this is a necessary fact. But we know too little of gravitation to authorize us to make any such assertion. We do not know that gravitation is essential to matter. We neither know what it is, nor how it acts; and, for any thing we know, it might have followed one ratio of action just as well as another. Therefore we have at least as good a right to attribute the established ratio to choice, as others have to attribute it to necessity.

But, without dwelling on this point, how shall we account for the velocity with which each planet moves, being so proportioned to the quantity of matter in the planet, and to its distance from the sun, as to retain it exactly in its orbit? Take any planet, and make an alteration in any of those conditions, and you derange or destroy the system. If you greatly increase the matter of any planet, leaving its distance and velocity the same as at present, it will fall into the sun. If you considerably increase the velocity, leaving the planet with the same, or less quantity of matter, and at the same distance from the central body, it will no longer move in an orbit nearly circular, but will describe a very eccentric ellipse, or fly off into the immensity of space. Here, then, design, nay, consummate wisdom, is displayed, in so finely balancing the centripetal and centrifugal forces, that the planets should move in orbits nearly circular. In order to the accomplishment of this, both the direction and the velocity of the projection lie within extremely narrow limits. Although the direction in which the body was projected had been right, yet a small difference in the velocity would have made a great change in the orbit; and supposing the velocity to have been just what it is at present, if the projection had not been in one particular line, the effect would not have answered. No direction would have cured a wrong velocity, and no velocity would have cured a wrong direction. Both must be right, and the right point lie within extremely narrow limits. Now, that two such independent circumstances should be found so exactly united, in so many different bodies, is evidently the result of contrivance and wisdom.

There is a fixed relation between the periodic times of the primary planets, and their mean distances from the centre. The squares of the periodic times are to each other as the cubes of the mean distances. That this should obtain in all the planets cannot be accounted for but by resolving it into design; and the fact is the more worthy of attention, when we consider that one of the conditions requisite to the stability of the system is, that the planets should perform their revolutions in different periods.

The framers of theories have amused themselves and their readers with dreams of comets striking off fragments from the sun, and of these fragments becoming planets. But, according to the great law of gravitation, a revolving body returns into its own path; and consequently, if the planets had been struck off from the body of the sun, they must in every revolution have returned to the body of the sun again. It is of no avail to allege, that the blow which struck off the fragments from the sun, removed the sun himself from his place; for, even in this case, as the supposed stroke acted on the fragment as well as on the sun, so the fragment must, in every revolution, return to the surface of the body from which it was broken off. As a revolving body, according to the law of gravitation, must return to the place from which it was projected, it follows that the planets must either have been formed in their orbits or carried to them, and received the projectile impulse there. They must all have begun their motions in their orbits.

We may here remark, that it has been said, that the four newly-discovered planets are fragments of a large body that formerly revolved in an orbit between those of Jupiter and Mars, but which, by some unknown cause, perhaps by a shock of electricity, had been broken in pieces; and it has been supposed that the meteoric stones, which sometimes fall on the earth, are the splinters of that large orb which gave birth to the newly-discovered planets. On this fanciful theory, I shall just observe, that if a large planet has been broken, it must have been many ages ago; for the history of astronomy does not inform us of any planet that has disappeared. Meteoric stones, however, have lately fallen on the earth. Are we not, then, left to suppose that the larger fragments, by some good fortune, have been honored with a place among the planets, whilst the unlucky little splinters have been wandering up and down for ages, without finding a resting place, till at length chance conducted them to this earth for repose?

Suppose a large planet to have been shivered, no matter how, we may inquire in what manner the large fragments acquired their spheroidal form. How did they find their way to their respective orbits? Whence did they receive their projectile force, so exactly in the direction and with the velocity requisite to ensure their continuance and steady motions in their orbits, amidst so many soliciting and disturbing powers? How came they to move so near each other, and yet to remain so distinct? Till these and similar questions be satisfactorily answered, it will be as philosophical to believe that the four newly-discovered planets were formed in their orbits, and projected by a powerful and wise Intelligence, as to embrace the theory now mentioned concerning their origin.

After the planets are projected in a direction and with a velocity so exactly proportioned to the quantity of matter in each, and to its distance from the sun, as that they shall nearly describe circles, still there is no physical necessity for their revolving on their own axes. But that most of them do revolve on their own axes we certainly know. That this should happen in so many different bodies, must be the result of design. Those persons who are best acquainted with the doctrine of probabilities, will not, I apprehend, ascribe it to chance. By this constitution of things a beneficial purpose is served, in our world at least, and we have not the means of judging so fully of any other. To it we owe the agreeable vicissitude of day and night, a vicissitude accommodated to our nature, as it gives us the opportunity of refreshing ourselves with sleep by night, to prepare for the toils and enjoyments of returning day. Here design is obvious; and benevolence characterizes the designing Mind, for the end is beneficial. Wisdom, also, plainly appears in the contrivance.

All the twenty-nine primaries and secondaries, belonging to our system (if the moons of Uranus, the planes of which are nearly at right angles to the orbit of their primary, be not considered an exception), perform their revolutions in the same direction. In the zodiac they all proceed from Aries to Taurus: none of them moves in the opposite direction. The diurnal rotations, so far as we know, all follow the same course. It is impossible to ascribe this to chance: it must be the effect of design; for, considered as casual productions, the chances of their all moving in a direct, and none of them in a retrograde course, are almost incalculable.* That the planets should all move in the same direction, in their orbits, is essential to the stability of the system; † for, had it been otherwise, the inequalities would not have had their regular periods of increase and decrease, as at present, but would have gone on increasing till they brought on the destruction of the whole fabric.

It may be inquired, whether the planetary system be steady and permanent. Are there no principles of dissolution operating in the apparently harmonious combination of globes? Are there no soliciting and disturbing causes which shall ultimately accomplish the overthrow of the whole? To such queries we answer, that in every system of bodies gravitating towards a centre, and reciprocally acting upon each other, there will be perturbations; and such perturbations exist in our system. The planes of the planetary orbits are subject to a variation in their situation: the inclinations of the orbits to the ecliptic are liable to a change: the figure of the earth's orbit is approaching towards a circle; and, owing to this cause, the mean motion of the moon is increasing: the obliquity of the ecliptic is diminishing. But have these changes no limits? Will they go on increasing till they terminate in the dissolution of the system? To these questions the investigations of modern science enable us to reply, that these changes have limits; and that the variations, irregularities, or inequalities of the solar system are periodical, and return into themselves. The whole oscillates round a certain position from which it can never greatly depart. These variations travel their rounds in fixed periods. The periods of some of them are short, while those of others involve hundreds of years. But still, at the close of their respective periods, each

* La Place has calculated, that the probability of the motions of the solar system have taken place without the operation of a superintending mind is so small, that it may be considered as nothing. It is as $2 : 2^{42}-1$; *i. e.* it is as 2 is to 4398046511103. These motions alone furnish an almost decisive proof of the existence of a designing cause.

† As the planes of the satellites of Uranus are nearly perpendicular to the orbit of the planet, the direction of their motion, whether retrograde or otherwise, can have no sensible influence upon the system.

returns to the point from which it set out, and is found in its orbit as if no such disturbance had happened. After certain periods, the planes of the planetary orbits will return to the positions from which they departed; the inclinations of their orbits to the ecliptic will return into themselves; the figure of the earth's orbit will come back to its original form; and the mean motion of the moon will decrease by the same steps by which it has increased. The obliquity of the ecliptic will never change above two degrees; and, vibrating within such narrow limits, the seasons will never be sensibly affected by it.

For the permanency of the system necessity cannot be pleaded, as it depends on conditions which are not necessary. These conditions are, that the attraction be inversely as the squares of the distances; that the orbits be not far removed from circles; that the planets all move in the same direction; and that the planes of their orbits are not much inclined to one another.* These conditions are not essential to a system of bodies mutually gravitating towards each other. They do not necessarily arise from the action of any physical cause known to us. Any of them might be changed, while the others remained the same. The appointment of such conditions, therefore, as would ensure the stability and permanency of the system, is not the work of necessity; it cannot be the work of chance, for chance could never have brought together such an assemblage of independent conditions. It must, therefore, be the work of design; yea, of boundless wisdom, which, at one comprehensive glance, saw the system in all its variety, and perceived the conditions essential to its permanency.

The comets are bodies of little density, and, consequently, their disturbing power is little felt on the planets.†

Having made these observations on the solar system, let us now glance at the fixed stars.

* This last condition, it may perhaps be alleged, does not hold in some of the new planets; but these planets are very small bodies, and their action on the system must be altogether insensible.

† The very different positions and inclinations of the orbits of comets to the ecliptic seem not to be the effect of chance; but give us reason to acknowledge and admire the wisdom of Deity. If the planes of their orbits had been in that of the ecliptic, or very near it, then every time that a comet descended towards the sun, or returned from its perihelion, we would have been exposed to the danger of being struck by it, if, unhappily, the earth had then happened to be at the point of intersection; or at least, according to Whiston, we would have run the risk of being inundated by its tail. But according to the present constitution of things, this risk is avoided.

On departing from the orbit of Uranus, the remotest of the planets, so far as we at present know, we must traverse, in all probability, between two and three hundred thousand times the distance of the earth from the sun, a space which we may compute in numbers, but which imagination can scarcely conceive, before we reach the nearest of the fixed stars.* From that point, sound would take millions of years to travel to our earth. Notwithstanding this immense distance, some of the fixed stars, probably the least remote, such as Sirius and Arcturus, shine with great brilliancy. In a clear night, by reason of their twinkling, they seem to be innumerable. But, in reality, the number discernible by the naked eye is not very great, being only about three thousand; and it is but seldom that one third of that number can be seen, even by a good eye, at the same time. On using a powerful telescope, however, their numbers exceed calculation. They are clustered throughout the immensity of space in such multitudes as to bewilder the imagination in their countless number, and in the inconceivable extent of the universe.†

They shine by their own light. The delicate discovery of the aberration of the fixed stars shows that the velocity of their light is the same as that which comes from the sun. It is also capable of the same modifications as the solar light, being reflected and refracted according to the same laws. Hence it appears that the sun and the fixed stars are bodies of the same nature; and, according to the opinion of the most enlightened philosophers, these stars are so many suns, each surrounded with its own planetary system; although, on account of their immeasurable distance, these planets are altogether invisible to us.

We speak of these stars as fixed, because they preserve the same relative position with respect to one another. But there is no clear evidence of their absolute immobility. Sirius, Arcturus, and Aldebaran, have been observed to make a small change in their places; and, according to some, the solar system is not confined to a certain region in absolute space, but has a progressive motion. Perhaps all the great

* The annual parallax of the fixed stars has not yet been ascertained. But if we suppose it not to exceed 1″, the distance of the fixed stars cannot be less than 206265 times the radius of the earth's orbit. As light traverses the latter in 8′ 13″, it will require 3 years and 79 days to come from a fixed star to the earth.—PLAYFAIR.

† The more powerful the telescope, the greater is the number of stars seen. La Lande computed that, with a forty feet telescope, a hundred millions were visible.

bodies of the universe are grouped together in systems, mutually supporting each other, and moving in orbits round a central point in the immensity of space; or they may be supported in their stations in a way of which we have no conception. For although we see processes of vast extent going on, and principles of wide operation established, yet we are not to confine the Supreme Architect to these principles and processes only, because we know of no other. We see enough to convince us that He can vary his means as circumstances require, and that no end is beyond his powers of execution.

What a great and glorious scene, then, do the heavens exhibit to our view! Millions and tens of millions of suns are stationed at convenient distances throughout the immensity of space, enlightening, and warming, and fertilizing hundreds of millions of worlds, all wheeling in busy and silent revolution round their several points of attraction, or bound together in systems of mutual gravitation. Judging from analogy, and from all that we can perceive of the operations of Him who never works in vain, we are constrained to conclude that all these worlds, formed, and projected, and guided by the potent arm, and under the immediate inspection of the Almighty Sovereign, are inhabited by different orders of beings, with organs accommodated to the different circumstances in which they are placed, and endued with different degrees of intellectual capacity. What a noble scene! How ambitious ought we to be to extend our acquaintance with it in the progress of our existence! If creation be so great, O how great must the Creator be! He not only made, but he upholds and governs, the mighty system of the universe. Not a movement of any orb but is guided by his hand; and not an action of a rational creature that escapes his eye. How well is he entitled to our homage and obedience!

Our earth, in all its beauty, variety, and magnificence,—oceans, lakes, and rivers, mountains, valleys, and plains, clothed with verdure and enriched with plenty, diversified and enlivened with numerous inhabitants,—presents a rich and charming scene to the imagination. But when we contemplate the number and magnitude of the heavenly orbs, the myriads of worlds profusely spread throughout the immeasurable regions of space, upheld by almighty power, arranged and directed by consummate wisdom, replenished with inhabitants, many of whom, no doubt, occupy a higher station, are endued with nobler powers, and clothed with a brighter glory than man,—then the magnificence of our earth dwindles away, and the dignity of our nature and race seems absorbed in the brilliancy of the mighty constellation of intellectual being. Instead of overpowering our faculties, or damping our energy, let the view elevate the soul, awaken the ambition, and invigorate the exertions of rational and immortal man. Let him rejoice that he forms a part in such a mighty scheme; that he stands so high on the scale of existence Other beings may be endued with more vigorous and enlarged faculties; but he is not doomed to remain stationary in the place which he now occupies. His powers are capable of high improvement; and who shall set limits to his progress in the pursuit of excellence? What attainments are within his reach, how far his faculties may yet expand, what noble rewards may yet crown his diligence and activity, and with what dignity he may yet appear among the chosen of the universe, no language can express, nor imagination conceive.

The wise and benevolent Sovereign of Nature, reigning with vigilant affection over innumerable worlds, peopled with inhabitants whose organs are suited to their respective situations, all rejoicing in the existence, adoring the perfections, and grateful for the goodness of the bountiful Creator;—what a magnificent and ennobling scene! While the melody of praise and the incense of thanksgiving ascend from all quarters of the universe towards the throne of the Almighty, what shall we think of those few beings, perhaps of our race chiefly, who refuse to join in the general symphony, and who not only withhold the tribute of adoration and gratitude, but audaciously deny the existence of the Creator? Guilty and miserable creatures! they cast themselves out from the great society of blessed intelligences, and forfeit the felicity prepared for the grateful and obedient subjects of the Universal Sovereign.

In our cursory glance at Nature, we have seen a wonderful scene,—minute precision, and splendid magnificence; striking uniformity, and endless variety; apparent carelessness and irregularity, and the most perfect order and exquisite arrangements, all united. In examining the parts, we meet with skilful contrivance, admirable workmanship, and exact adjustment. As there is an accurate adaptation and reciprocal dependence of the parts, so those parts are combined in one harmonious and magnificent whole. Obvious traces of design every where occur; and as certainly as design proves a designing cause, so certainly do we prove the existence of an intelligent Creator. We do not, indeed, see or feel the Deity, in the same manner as we see or feel a material object. But although he himself is invisible, his operations are manifest. Creation proclaims the being of the Creator. The attributes of mind are evidently displayed; and the existence of God is as fully ascertained, as if we saw him with his right hand upholding the sun, with his left directing the stars in their courses, and heard his voice proclaiming, "I form the light, and create darkness; I, the Lord, do all these things."

BOOK III.

THE PERFECTIONS OF DEITY.

CHAPTER I.

THE UNITY OF DEITY.

Design and contrivance are fully established by the facts and arguments stated in the preceding part of this treatise. But design and contrivance are acts of mind, and their existence in the universe plainly proves it to be the production of an Intelligent Cause. We now, therefore, proceed to inquire into the character of the Supreme Intelligence, in so far as it is discoverable in the works of his hand. We indeed know, and perhaps at present we can know, but little about the Divine Essence, and the manner in which the Deity exists and acts; but our ignorance or imperfect knowledge of those things is not even a shadow of argument against the existence of the Supreme Being. It is nothing more than a proof of our limited capacity. In investigating the character of the Deity, as discoverable from his works, we may assume it as a principle, that whatever qualities appear in the design and contrivance, may justly be ascribed to the designing and contriving Mind, in the degree, at least, in which they are manifested in the design and execution. For instance, the planets, bodies of vast magnitude, have been projected with prodigious velocity; and that velocity and the direction have been so nicely adjusted to the quantity of matter in each of the planets, and to their respective distances from the sun, as to make them describe such orbits as shall ensure the stability and permanency of the system. We cannot err in ascribing to the Author of the system a power equal to the projection of the planets in their orbits with the requisite velocity, and a wisdom equal to what was necessary in order to the establishment of such conditions as are sufficient for the security of the system. And in so far as the constitution of things promotes the happiness of sentient beings, the attribute of goodness must also be admitted.

Although we cannot err in ascribing to the Deity those attributes which are manifested in creation, and in that degree in which they are there displayed, yet we are not to limit the perfections of God by his works. Before we can pretend, from the works of Deity, to set limits to his attributes, two conditions seem to be requisite. First, we must completely understand the work in all its extent. Secondly, we must perceive some defect in the obvious plan, which could arise only from a limitation of the perfections. If the plan be perfect in its kind, we are not authorized to infer that he who contrived and executed it was unable to have contrived and executed a nobler plan. Because the architect has built a cottage, we are not to conclude that he was incapable of constructing a palace. He has executed his plan; and we have no evidence of his incapacity for a more extensive and splendid work. If the present work be well finished, according to the obvious design, the presumption is, that he could equally well have built a more superb mansion if he had undertaken it.

In like manner, while we ascribe to God all the perfections manifested in his works, we are not to imagine that all the resources of his perfections were exhausted in the execution of those works which fall under our inspection. He has exercised all that perfection which his plan required; and the presumption is, that he could have exercised more if more had been needful. For example, mighty power is displayed in the projection of the planets; but we are not authorized to infer that all the power of God was exerted in that projection. The power requisite in order to the accomplishment of the end was exerted; the exertion of a greater degree of power would have been subversive of the end; and, therefore, the exercise of power was regulated as well as directed by wisdom. A similar observation may be applied to the other attributes of God. In judging of his perfections from his works, we must not lose sight of his plan, and we are to ascribe to him all the perfections manifested in the plan, and all that by legitimate reasoning can be deduced from the execution of it.

It is reckoned a fundamental rule in philosophy, not to suppose more causes than are needful to produce the effect. This principle conducts us to the unity of Deity; for the necessity of finding an adequate efficient cause does not compel us to have recourse to a plurality of gods. The power that was equal to the creation of a part was equal to the creation of the whole. But we are not obliged to rely on a principle of this kind, in order to establish the unity of Deity. The uniformity of plan that pervades the system indicates unity of counsel, at least in its formation. We can trace unity of plan in the great fabric of the universe, so far as we are capable of observing it. The law of gravitation prevails throughout the solar system. All the bodies in that system seem to revolve on their own axes: all the planets move in the same direction in the zodiac. The light of the fixed stars affects the eye in the same way as that of the sun; and it travels at the same rate, as we learn from the delicate discovery of their aberration. On descending to our earth, we find a similar uniformity prevailing, and can easily trace the harmonious combination of many great parts into one magnificent whole.

The earth is a component part of the solar system; and in it many independent conditions must meet, in order to render it a convenient residence for beings organized as its present inhabitants are. It is a terraqueous globe, clothed with an invisible aërial robe; and the dry land is covered with a mould capable of imbibing moisture and supporting vegetation. The earth is enlightened and warmed by the sun, the central body of the system. If the earth had been a detached body, wholly unconnected with any other orb, darkness and sterility would have established upon it an everlasting empire. But the sun is provided; a condition essential to vegetable and animal existence. The atmosphere also was requisite. It refracts and reflects the beams of the sun in all directions, and sheds a flood of light on the earth. The sun exhales vapors from the ocean; the atmosphere supports those vapors, and by its currents carries them to the dry land, where they descend in refreshing showers, affording nourishment to vegetables, and a wholesome beverage to man and beast. With all the conditions mentioned, the earth might have been the mansion of melancholy silence and eternal sterility; for the sun, the atmosphere, the ocean, the soil, cannot produce a single blade of grass, or a single herb, or a single tree, without seed. But seed is liberally provided; and hence the earth is clothed with verdure and enriched with plenty.

The sun, however, might have beamed in the firmament, the rain distilled on the tender plant, and luxuriant herbage crowned the mountain and waved on the plain, without a single sentient being to enjoy the scene, or partake of the rich feast which the bountiful Creator had provided. But God does not work in vain. Having fitted up such a noble habitation, he replenished it with tenants of many different kinds, all capable of enjoying the accommodations with which it is stored, and of relishing the happiness which it is calculated to afford. There are perhaps 20,000 different kinds of living creatures upon our globe. Among these there is a great variety; but at the same time a uniformity so striking, as to indicate the same skilful hand in their formation. They all respire by lungs, gills, or air-tubes. All animals take in food: in all, the processes of digestion and assimilation are carried on; and an excrementitious part is thrown off. They all propagate their kinds.

Vegetables draw sustenance from inorganic matter, and prepare food for sentient beings. Plants have their appropriate vessels for conveying the sap and peculiar juices through the stem, branches, and leaves; animals have blood-vessels for an analogous purpose. The gradations in the animal world all proclaim the workmanship of the same hand. Here we see a very complicated system: many independent parts are combined into one harmonious whole. The different parts of nature are admirably adjusted to each other. The relations between the different parts of the system; between the sun, the earth, the air, and the ocean; between the animate and inanimate parts of creation, direct us to one powerful Creator.

One agent is often made subservient to many different purposes. One sun illuminates many worlds; the light and heat which emanate from that luminary answer many valuable ends. To man the uses of air and water are multifarious. The ocean is also the seat of much enjoyment, and the air the chief scene of felicity to many a happy being. In travelling over the earth, we meet with different climates; nature puts on various aspects; and nations differ in their appearance, manners, and laws. Still we meet with nothing indicating the hand of a different artist, or the government of a different sovereign. All nature points to one great Author. Unity of plan pervades the universe; and from this unity of plan we may fairly infer the unity of Deity. One Supreme Mind planned the great system of nature, still upholds it in existence, and continually superintends the government of the whole.

CHAPTER II.

THE POWER OF DEITY.

That the Deity is an all-powerful Being evidently appears from his works. The Architect who could build the stupendous fabric of the universe must be omnipotent. We can conceive no bounds to the power of Him who was able to station the sun in the firmament, and to launch the planets with such velocity in their orbits. Limiting our view to the solar system, which is merely a speck in the immensity of space, and amid the myriads of worlds with which space is replenished, must we not be amazed on beholding the sun in majesty occupying a central position, and presiding over the great globes, which in silent and unceasing revolution wheel around him? Think on the dimensions of the planets, and their rapidity in their orbits. What a potent arm must have projected, with such prodigious velocity, those vast bodies into the illimitable void! Our earth, almost eight thousand miles in diameter, travels about fifteen hundred thousand miles in a day; and, at the same time, it is spinning on its own axis, and turning up, successively, the vegetables and animals which it nurses on its bosom, to the genial influence of the solar rays. And, with this inconceivable rapidity, how unceasing, steady, and uniform, are its motions! The same holds in the other planets, some of them vastly larger than our globe. Each of them regularly and steadily performs its revolutions. The Power capable of producing those effects is immeasurably greater than what we experience in ourselves, or perceive in any visible agent, and may with propriety be described as omnipotent; because nothing in our observation or experience authorizes us to set limits to it.

We ascribe *infinity* to all the attributes of Deity. But infinity is a word to which we can attach no precise conceptions. The very use of the word is an admission that the thing to which it is applied is above the grasp of our comprehension; and when applied to any of the perfections of Deity, it means that those perfections go as far as our minds can follow them, and how much farther we cannot tell. And certainly, when we contemplate the power displayed in the universe, and the numberless instances and incalculable variety of the manifestations of wisdom and goodness, we may, with reverence, admiration, and gratitude, describe those perfections of Deity as infinite.

It is obvious that the Power which could create the world is able to uphold it in being. God must preserve the world which he has created, for that which derived its existence from another does not necessarily exist. It could not so exist in the first moment of its being, nor yet at any future period; and must, consequently, owe the continuance of its existence to HIM from whom its being was primarily derived. There is no medium between necessary existence and dependence on a cause. A creature can no more preserve than make itself.

There is an essential difference between creation and works of art. For though works of art cannot make themselves, yet, when made, they can continue to exist without the artist who made them. A house cannot build itself; but, when built, it stands as long as the materials and workmanship last. We must observe, however, that the artist merely gives a particular form to that matter which depends on the power and will of the Creator for the continuance of its existence. The particular form given by the artist exists in subjection to the laws which the Creator has established for the government of that matter which he upholds in being. Although the facts that God at first created, and that he still preserves all things, are clear, yet the manner of creation and of preservation are equally above our reach.

CHAPTER III.

THE WISDOM OF DEITY.

WISDOM is manifested in employing fit and adequate means for the accomplishment of its ends. It obviously appears to have been the purpose of God that this world should be a proper place of residence for animals of many different kinds, and that all the animals should enjoy the means of preserving, for a time, the life of the individual, and of continuing the species. These ends are completely accomplished, and accomplished by such a complicated and diversified combination of independent circumstances as gives a most exalted view of the divine wisdom. This world was to be fitted up as a place of residence for its present inhabitants. For this purpose, light and heat, and air and moisture, were necessary. Accordingly, the sun was provided to enlighten and to warm the earth; a vast basin was scooped out, and the waters of the ocean poured into it; the atmosphere was thrown around the earth to be the carrier and dispenser of this moisture exhaled by the sun.

Between the animated and inanimated parts of nature we see the most astonishing relations. There is a fine correspondence between the atmosphere and the respiratory organs of animals. These organs are very different in different living creatures; but in each they are wisely accommodated to the configuration and circumstances of the animal, and in all they accomplish their great vital function. In the atmosphere, and in the organs of respiration in connection with the other parts of the constitution, we have an adequate provision for the existence of the animal; but it is subject to a daily and hourly waste, and needs a frequent supply. This supply is provided, as well as a complete apparatus for taking it into the system.

The earth is clothed with a great variety of vegetables, which extract nourishment from inorganic matter, and afford sustenance to man and beast. All the different animals are furnished with means of subsistence; and when we attend to the manner in which every animal is fitted for collecting, eating, and digesting its food, we perceive a display of consummate wisdom in the admirable adaptation and combination of means, in order to the accomplishment of an end. As wisdom undeniably appears in the complete provision made for the preservation of the individual, so it is equally manifest in the efficacious means which are employed for the continuation of the species. Some classes of animals live longer and some shorter, but all are capable of continuing their kinds; and we see a wonderful system established, for nursing and protecting the young till they are capable of providing for themselves. No species perishes either through a failure of the means of subsistence to the individual, or from incapacity to continue the species; and the reproductive powers of the several kinds are adapted and proportioned to the term of their existence, and to the dangers to which they are exposed.

When we, then, consider the boundless extent and vast variety of things, the skilful adaptations that every where occur, and the beautiful order and regularity that prevail in nature, we must pronounce Him who was capable of conceiving and executing such a plan a Being of infinite wisdom. His wisdom no difficulty can baffle; it is equal to every emergency. In every possible combination of circumstances, he at once perceives the best plan, and the best means for carrying that plan into execution. But on the wisdom of the Creator we have already had frequent opportunities of remarking, when contemplating particular parts of his works; and, with respect to man, considered as a moral agent, a number of observations relating to this attribute of Deity will present themselves, in a subsequent part of the treatise.

CHAPTER IV.

THE GOODNESS OF DEITY.

The same observations which prove the wisdom of Deity, may, in general, be adduced as evidences of goodness; for if the end to be accomplished promote the happiness of sentient beings, then every display of wisdom in the accomplishment of that end is a demonstration of benevolence; and, in most instances, the same facts which demonstrate wisdom, prove benevolence also. In order to prove malevolence, or even the absence of goodness, it would be necessary to show that the life of the individual is a state of misery, or utterly destitute of enjoyment, and that the preservation of that life, and the continuation of the species, are merely a prolongation of suffering, or of insipid existence. It would be necessary to prove this, not in a few insulated cases only, but to show that it predominates in the system of nature. A proof of this kind no person in the right use of reason will attempt.

Dr. Paley rests the proof of the divine goodness on the two following propositions:—

1st. "That, in a vast plurality of instances in which contrivance is perceivable, the design of the contrivance is beneficial."

2d. "That the Deity has superadded pleasure to animal sensations beyond what was necessary for any other purpose; or when the purpose, so far as it was necessary, might have been effected by the operation of pain."

Both of these propositions can be clearly established; and the establishment of them proves the goodness of Deity. I shall therefore make a few observations in illustration of them.

1st. "In a vast plurality of instances in which contrivance is perceived, the design of the contrivance is beneficial." This proposition I am inclined to render more general than it is stated by Dr. Paley. For in animated nature, which is the region where goodness is felt and enjoyed, I know of no instance of contrivance which is not beneficial to the being which is the object of that contrivance. The benefit of the contrivance is indeed more obvious in some cases than in others: in most cases, I believe, it may be perceived; and in no instance can it be shown to be injurious. It is obvious in most of the organs of sense; and all the organs of sense are undeniably beneficial. Are not the articulations of the bones beneficial? Is not the configuration of the alimentary and intestinal canal beneficial? Are not the hoof of the horse and the paw of the lion beneficial? Take any animal, and, in attending to the whole, or to any part of its organization, you will find it adapted to the manners and circumstances of the animal, and conducive to its existence, security, and happiness. Consider the vast variety of sentient beings, as well as the various contrivances in their structure, and when you reflect that all these are conducive to their welfare, you must be astonished at the comprehensive beneficence of the Creator.

The goodness of Deity is manifested in the liberal provision made for the subsistence of every living creature. There is a relation strongly expressive of benignity between animated and inanimated nature; for the earth produces a sufficiency for the subsistence of all the living beings upon it; and in life all animals seem to have enjoyment. The heart of him who sympathizes with the inferior creatures in their pleasures, will often be delighted on contemplating their felicity, and will feel its own happiness increased by witnessing their enjoyments. If we turn to mankind, they, also, enjoy much felicity. Even after all the evils that we bring upon ourselves by the abuse of our free agency, we are oftener in health than in sickness—oftener in joy than in sorrow. That there are sorrows and pains, is evident; but in human life they do not preponderate. They will engage our attention in a subsequent part of the work.

2d. "The Deity has superadded pleasure to animal sensations, beyond what was necessary for any other purpose; or where the purpose, so far as it was necessary, might have been effected by the operation of pain."

If it be the will of the Supreme Being that sentient creatures shall exist, he must endow them with the means and capacities requisite to the continuation of their existence. But those means might answer the end, without contributing, in any degree, to the happiness of the animal. They might demonstrate power and wisdom, and yet be no proof of goodness. For instance, food is necessary to the support of animal life; every animal, therefore, must be provided with the means of taking in food; and if these means be well adapted to the end, they certainly demonstrate wisdom. But the act of eating might be attended with no pleasure; nay, it might be attended with positive pain; and the animal might be prompted to it merely by the desire of removing a greater pain by submitting to a less. If there be enjoyment in taking in food, which is certainly the case with all animals, then this is a demonstration of goodness in the Creator; for it shows that he has superadded pleasure beyond what was necessary for the accomplishment of the purpose.

The organs of sense were either necessary to the existence of the animal, or they were not necessary; but, in either case, they prove goodness in the Deity. For if we consider them as necessary, still they might have performed their office without communicating any positive pleasure; but, in fact, they are all sources of enjoyment to the creature, and consequently proofs of goodness in the Creator. If we consider them as not necessary, the proof of goodness is, at least, not weakened. For, in this case, they must have been bestowed merely as inlets to happiness, and are marks of gratuitous goodness. If we glance at the organs of sense, however, we shall find them not only useful, but also sources of pleasure. What a variety of enjoyments do we obtain by means of the eye! That it is a large inlet of felicity, no person in the right use of reason will deny. But if the Deity had been a malevolent being, this organ might have been the occasion of incredible infelicity and pain. In a diseased state, it sometimes cannot bear the light. Unless the Deity had been benevolent, the eye, even in its natural state, might have been as much or more irritated by the action of light, than it presently is even when diseased. Compare, then, the difference between a sound and a diseased eye; consider that the latter might have been the natural state of the organ, and certainly you will acknowledge the goodness of Deity.

Our minds are so constituted, that we receive pleasure from the sight of many objects in nature: they might, however, have been so constituted that the sight of those objects would have been a source of perpetual irritation and pain. The verdure of the earth, which is so grateful to the eye, and the variegated landscape, the mountain and the wood, the valley and the stream, so exhilarating to the mind, might have produced a contrary effect, and might have weighed as much in the scale of pain, as they now do in that of pleasure.

What is true with respect to the eye, also holds of the other organs of sense. The ear is a source of much enjoyment. Music yields high gratification, and often soothes and cheers the mind under the anxieties by which it is assailed. But the ear might have been otherwise constituted. It might have been so formed, that the gentlest whisper would have acted as powerfully upon it as a peal of thunder now does; and that the most melodious note would have been as grating as a piercing scream. How much more felicitous is our present condition, than what it could have possibly been in such circumstances!

The sense of smelling, also, not only contributes to our security, but greatly promotes our happiness. How exhilarating is the breeze impregnated with fragrant odors! How sweet the scent of the fields after a gentle summer shower! If the Deity had not been benevolent, we might have been so constituted that every object around us would have affected our olfactory nerves as disagreeably as assafœtida, or even the intolerable stench of the zurilla. Taste, likewise, is a source of much pleasure. But if a malevolent being had been the author of our existence, every thing might have been made to taste like gall and wormwood. Feeling, also, might have been the cause of great suffering; for every thing we touched might have irritated like a nettle; but at present it is the source of much pleasant sensation. All our senses are wisely and beneficently accommodated to our nature and circumstances, and so formed as both to contribute to our security and to promote our happiness. When we enjoy health and the approbation of our moral nature, how cheerful and happy do we feel! Notwithstanding the murmurings of the querimonious satirist, or the complaints of the discontented philosopher, man really is, or may be, a happy being. Nature around him wears the aspect of placid satisfaction, exhibits cheering scenes of active enjoyment, and utters the gladdening note of felicity.

The goodness of Deity appears not only in the general structure of our body, and in the formation of the different organs of sense, but also in that constitution of animated beings in which there is an effort to heal wounds and expel disease. The slightest bruise might have festered, and, like the breaking out of waters, might have increased till it demolished the organized fabric. But nature makes a healing effort, and often wonderfully succeeds. This, however, is not all. Medicinal substances are provided in the mineral, vegetable, and animal kingdoms, of which man may avail himself to aid the efforts of his constitution in healing wounds and curing diseases. Here, as in every department of nature, we meet with an order of things fitted to awaken the curiosity, invite the research, reward the ingenuity, and increase the happiness of man.

The goodness of Deity has provided means not only for healing wounds and curing diseases, but also for aiding our organs of sense under the infirmities of nature and the decays of age. The eye, for instance, is a beautiful and useful, but delicate organ. It is liable to infirmity and decay; but spectacles may be made to assist the sight under almost every configuration of the eye, and in every period of life. Similar remarks may be applied to the ear; and the eye and the ear are two great inlets of pleasure. An observation of the same kind may be extended to our bodily diseases. The malignity of the small-pox was greatly mitigated by inoculation, and appears to be still farther subdued by vaccination. These remarks show wisdom and goodness plainly engraven on the face of nature; for those attributes evidently predominate, so far as our observations extend. But before we are able to explain all the phenomena, and to answer objections, we must have some conception of the plan of Deity, particularly in reference to man, who is unquestionably the chief living being on this earth. He stands at the head of the animal creation on our globe, and the scheme of government which he is under, must, to a certain extent, affect the destiny of the inferior creatures. The uniformity of the system requires that, in so far as they share a common nature with man, they shall be under the operation of common laws.

In forming an estimate of the perfections of God from his works and government, we must attentively consider the end he has in view. To form some imaginary scheme of our own, and to pretend by that scheme to measure the divine perfections as exhibited in the conduct of a very different plan, is altogether absurd. We must take the plan of God, as it may be fairly collected from the established system of things; and if that plan, and the means employed for carrying it on, be compatible with wisdom and goodness, then all objections against the divine perfections, arising from some imaginary plan of our own, are nugatory. I shall, therefore, in the following chapter, attend to the character and state of man, which will lead to observations on the design and government of the Deity respecting him.

CHAPTER V.

THE CHARACTER AND STATE OF MAN.

Man is the lord of this world, and he is honorably distinguished from its other inhabitants by peculiar qualities. In considering his character and state, we observe that he is a rational and immortal being; that at present he is in a state of trial and discipline, under a system of moral government; and that his improvement and happiness are carried on and promoted by the exercise of his faculties. To each of these we shall for a little attend; and a careful contemplation of the phenomena will enable us to discover and understand the plan of God respecting him.

I. Man is a rational being. While the inferior animals are under the guidance of instinct, he is endued with nobler principles. Besides appetites, which he has in common with the brutes, he is dignified with intellectual, active, and moral powers, which they do not possess. Perception, memory, imagination, reason, a moral faculty, emotions, and a voluntary faculty, are wonderfully combined in his nature, and form a singular and interesting being. He can observe, compare, and judge; he can vary his means, and suit his operations to the circumstances in which he is placed. He can turn in upon himself, and trace the operations of his own mind. He can survey the vast system of the universe, discover the laws by which it is governed, and learn the attributes of the Creator and Governor from the works of his hand. He can surround himself by a new creation, and combine in endless variety the objects with which he is acquainted. He remembers the past; and the lessons of experience not only furnish him with instructions for the regulation of his present conduct, but also enable him to anticipate what he may expect from the future. He hopes and he fears; he loves, and desires, and pursues; he dreads and he shuns. His moral faculty indicates the path of duty, and it applauds or condemns. His intellectual and active powers are finely adjusted to each other, and form a being capable of much present enjoyment, and of vast improvement in intellectual and moral excellence. How absurd is it to allege that undesigning chance produced such an intelligent and contriving being as man!

II. Man is immortal. The Creator has not constituted him an ephemeral being. He is destined to inherit eternity.

And we are not driven to a future state in order to find a remedy against present disorders. The conclusion naturally results from a fair and candid consideration of the phenomena.

First, Our bodily fabric dies and is dissolved; but an opinion in favor of the immortality of the soul has almost universally prevailed in every age, and in every nation, among all ranks of men, and in every stage of society. It is not the badge of a sect, but the creed of man. We may find him without arts and without laws; but the sentiment of immortality seems every where, and in every period, to have been entertained. The mind is impressed with an involuntary presage of existence; and although the notion of a future state has been differently modified, according to the different circumstances of those who have believed it, still the same general notion has prevailed. On this subject, the joint opinion of mankind, respecting a matter of common interest, is the voice of their nature proceeding from the universal Parent, intimating to his children the happiness which they are formed to enjoy, and the dignity and perfection which they are capable of attaining.

Secondly, The doctrine of immortality, the grand problem respecting the nature of man, is attended with the same difficulty as the being of God, and arising from the same cause—the invisibility of the immortal principle. We are so much accustomed to bring every thing to the test of our bodily senses, and to be guided by their evidence, that we are disposed to withhold belief in cases where they are incapable of giving testimony. This, I believe, is a chief source of skepticism, both with respect to the being of God and the immortality of man. Some think that all the operations of mind are the result of corporeal organization, and hence they infer that mind must perish on the dissolution of the organized fabric. Our knowledge, however, is by far too limited to encourage us to lay much stress upon this inference, even although the premises from which it is deduced were correct. "I do not see," says Dr. Paley, "that any impracticability need be apprehended by these; or that the change, even upon their hypothesis, is far removed from the analogy of some other operations which we know with certainty that the Deity is carrying on."

For any thing we know, matter, under all its modifications and combinations, is incapable of intellectual operations. If the case should be otherwise, who can for a moment doubt the ability of HIM who could attach thought and volition to matter, to continue those faculties under different organical modifications. If the being of God be proved, the existence of invisible mind is proved; and the various and wonderful combinations in the universe may lead us reasonably to think that, somewhere in the scale of being, matter and mind shall be united. It has been correctly observed, that our notions both of body and mind are merely relative; that we can define the former only by the qualities perceived by our senses, and the latter by the operations of which we are conscious; and therefore the immateriality of mind is involved in the only conceptions of matter and mind that we are capable of forming.

The doctrine of immortality, how wonderful soever it may seem, is not more amazing than many facts presented to our daily observation. Man, at the hour of his birth, undergoes a mighty change in the means of his subsistence and mode of his being; and were he capable of anticipating that change, and of reasoning upon it, his life in the world would appear a problem as difficult as immortality does at present. Death may immediately, in the natural course of things, put us into a higher and more enlarged state of life, as our birth does. The one, like the other, may be a continuation and enlargement of powers.* After birth there is a continuation and enlargement of the same material fabric, which was formed before we saw the light. That fabric death dissolves: we have no reason, however, to conclude that death destroys the thinking principle. The vegetable dies, to live no more; but it cannot be fairly pleaded that man falls under the same law. The analogy does not hold; for the vegetable attains the utmost maturity of which it is capable, and it is wholly destitute of that which is the subject of our present consideration—the cogitative substance, the capacity of perfection and action. Now, it is about the continuation of this principle only that we are at present inquiring. Its material means and instruments of perception and action may be destroyed; but, in a future state, it may have organs of perception and means of communication, of which at present we can form no idea.

Thirdly, Organized bodies may be dissolved, and the forms and combinations of material substances altered. By these alterations, the qualities as well as the form of bodies may be changed. Our bodies are in a state of unceasing mutation; and these mutations, in many instances, greatly in-

* Butler's Analogy.

fluence our corporeal qualities; but the consciousness of identity is in no degree affected by those continual changes. Hence, as well as by the only conception which we are capable of forming of mind, we are led to infer that the thinking principle is a simple and immaterial substance; and if it be so, the dissolution of the body by no means involves the extinction of that principle. It may continue to exist, to think, and to will, after the material tabernacle in which it is at present lodged shall be laid in ruins. Indeed, it must exist as a thinking principle, unless it be annihilated; for it cannot perish by alteration of form or dissolution of parts, and that it will be annihilated we have no reason to suspect. From the will in Deity to create, we may infer the design to preserve; and of annihilation we have no instances in the material world. Forms are changed; but substances remain, merely passing into new combinations. A simple and immaterial substance, however, is not subject to a process of this kind. While it exists, it must exist with properties unchanged. The removal of its material instruments cannot alter its essential qualities. But still, like every other created being, the continuance of its existence depends on the will of the Creator.

Fourthly, Creation bears testimony to the wisdom and goodness of the Creator. All his plans are wisely contrived and executed; and we see nothing like a system of abortion in his works. All orders of organized beings seem to reach the utmost perfection of which their constitution admits, and to enjoy all the happiness of which they are capable. This is equally true of the plant and of the animal; and we have no cause to suspect that man is an exception from the general rule. He is endued with faculties capable of high progressive improvement; and we have no reason to think that, in this world, he attains to all the perfection of which his nature is susceptible, or that his powers of progressive excellence, either moral or intellectual, are exhausted. We not unreasonably presume, then, that he is destined to survive the stroke of death, and continue his progress in improvement in a more advanced stage of existence.

We do not here assume the wisdom and goodness of Deity to prove the immortality of the soul, in order that, by the doctrine of immortality, we may obviate objections against the divine attributes. No: we merely contend, that in so far as wisdom and goodness appear in the other parts of nature, they are exercised towards man. If they be so exercised towards him, he must reach all that perfection, and enjoy all that happiness, of which he is susceptible; for this seems a law which pervades the system of sentient being, and we have no evidence that man is an exception from it. Accordingly, he must make all that progress in excellence of which his nature is capable; but we think that his capacity of improvement is not exhausted in this world; and, therefore, we look for another, where all his faculties will be fully expanded and attain maturity.

Can we suppose that a creature endued with such noble faculties, and capable of such progressive improvement, shall, at once and forever, be arrested in his progress towards perfection? Has the Deity bestowed upon him powers capable of grand advances in excellence, and shall he stop him in his glorious career, blast his hopes, and destroy the fruit of all his toils? Has he inspired him with the sentiment of immortality, merely to disappoint him? With all his lofty capacities, attainments, and anticipations, is man merely an ephemeral being? Must his labors and his hopes perish in the dust? Must all the splendor of his moral and intellectual nature vanish, like the meteor which gleams for a moment, and is extinguished forever? Are all the intimations of his nature, and of the world around him, mere delusions? These things cannot be so. The phenomena of the universe justify no such suppositions. Every thing conspires to intimate a different result. The sentiments of humanity, and the perfections of God, as engraven on his works, bear testimony to the immortality of man. The faculties which have budded here shall blossom hereafter: the course of improvement begun in time shall be continued in eternity. How far his faculties may yet expand, to what degrees of excellence he may yet attain, and with what dignity he may yet appear among the rational offspring of the Supreme Intelligence, n language can express or imagination conceive. O my soul, still cherish, fondly cherish, the sublime hope of immortality! While the dark and cheerless infidel looks to the grave as terminating his existence, like a river drunk up by the sand of the wilderness, still fix thine eye on the ocean of eternity! Remember the grandeur of thy prospects, the loftiness of thy hopes, and study to think and act as it becomes a being who shall yet associate with the highest created intelligences in the universe, be engaged in the most exalted employments, and stand near the throne of the mighty Sovereign of Nature!

On this subject, I have merely glanced at the phenomena of nature and the sentiments of humanity; and I contend for the truth which they seem to establish. If the evidence of the immortality of the soul be not so clear and decisive as some might desire, it may be remarked, that a certain degree of obscurity is not unsuitable to a system of moral agency, where we are called upon to act on probable and reasonable grounds, without expecting such a degree of evidence as will irresistibly force conviction; for if we suppose conviction to be irresistible, and also that such conviction irresistibly regulates conduct, what is this but necessity? But that man either is, or ought to be, a necessary agent, cannot for a moment be admitted.

Further, the degree of evidence on this subject is sufficient to influence human conduct; for it appears probable, at least, that man shall exist in a future state of being, and that his condition in that state shall be determined by his dispositions and conduct here. What, in such circumstances, is the dictate of sound wisdom? It surely is, to live as if we were certain of a future state of existence; for by pursuing this course we cannot possibly be losers. If there be a future state, then, we shall gain all the advantages resulting from our wise conduct: if there be no future state, we lose nothing. Nay, we are gainers; for the dispositions to be cultivated, and the conduct to be pursued, in the view of a future retribution, are such as ensure the greatest share of happiness in a present world. On the other hand, if any, because the evidence of immortality is not so clear and cogent as they could wish, shall live in the total disregard of a state of future retribution, then, if such a state actually awaits them, is there not great danger of their having committed an irreparable error, and of having subjected themselves to a dreadful, perhaps irretrievable, loss?

II. Man is at present in a state of trial and discipline, under a system of moral government; and to fit him for this state he is constituted a free agent. He is endued with intellectual and active powers: he has judgment to know the meaning of a commandment, and ability to obey it. By "moral government" we understand the establishment and operation of laws for the direction of rational beings, and the enforcing those laws by rewards and punishments. The subject of such a government must be a free agent.

1. By the liberty of a moral agent we understand a power over the motives which affect the determinations of his own will; and we call man a free agent in the same way, and with the same limitations, as we pronounce him a rational being. Every man has a conviction that he is free, and acts

towards others in the persuasion that they also are free. Our deliberations, purposes and promises, all suppose liberty in ourselves; and our advices, exhortations and commands, suppose it in others. That man is a free agent appears to me indubitable. On this subject philosophers may talk, but consciousness and experience decide. I am conscious of freedom. I can weigh motives. I can judge which are most consonant to sound reason and to my best interest; and yet can decline regulating my conduct by them. I can choose and refuse. I can act agreeably to the convictions of my understanding, or I can pursue a different course. Advice and exhortation may influence conduct, but they do not impair liberty. The same is the case with motives; they may prompt to action, but they do not act. A necessary agent, whose actions are as irresistibly determined by desires or motives as a stone in falling to the ground is by the great law of gravitation, cannot be the subject of moral government. He is incapable of virtue or vice, and unfit for reward or punishment.

> "Not free, what proof could they have given sincere
> Of true allegiance, constant faith, or love,
> Where only what they needs must do appeared,
> Not what they would? What praise could they receive?
> What pleasure I, from such obedience paid,
> When will and reason (reason also is choice),
> Useless and vain, of freedom both despoiled,
> Made passive both, had served necessity,
> Not me?"

Necessary agency and moral government are altogether incompatible. The one of them naturally excludes the other. Every encroachment on free agency implies a corresponding limitation of moral government. A necessary agent can neither be praised nor blamed. Resembling a magnet traversing on its pivot, and turning towards the polar points, his will has no part in the determination of his actions. Such a being cannot, any more than the magnet, be the subject of reward or punishment. The determination of the will is the first part of the action, on which alone its moral value depends. Unless man be a free agent, there can be no more moral worth in any part of his conduct than in the beautiful coloring of a fly's wing, in the melody of a thrush's note, or in the neat construction of a chaffinch's nest. Moral government implies free agency.

2. Man is not only a free agent, but also an accountable creature. He is the subject of a moral government.

Some ancient philosophers, although they professed to believe in the being of God, yet taught that he gave himself no concern whatever about the affairs of this lower world. They represented him as enjoying a state of listless tranquillity and indolent repose above the clouds; inattentive to the actions, and careless of the destiny, of men. This monstrous doctrine was a proper sequel to the irrational creed, that the world had been formed, not by the power and wisdom of Deity, but by a fortuitous concourse of atoms. In order to the belief that God took no notice of the affairs of the world, it was necessary first to exclude him from any concern in its formation; for if they had admitted that all things were made by him, it would not have been easy to have proved that he had divested himself of all regard to the works of his hand, and, like an unnatural parent, had ceased to think of them, to love, and to protect them. But sound reason, contemplating all the phenomena, rejects as absurdities the dogmas of the Epicurean school, and pronounces that the Deity exercises not only a providential care over all his works, but also a moral government over man.

The providential care of the Almighty is evident in the preservation of the established order of things, so that an adequate provision is made for supplying the wants, and administering to the enjoyments, of sentient beings. He more particularly exercises the right of an equitable sovereign over his rational offspring. His will is to them a law, and this law harmonizes with the system of nature in proclaiming the benevolence of Deity, by promoting the happiness of man. The law is not the arbitrary and capricious volition of an Omnipotent Ruler. It emanates from wisdom and benignity, and is directed towards the general good, in a consistency with all the attributes of the Creator. The great principle of the law is utility; or, in other words, what the Deity, in his boundless wisdom, saw would be best, not merely for one or a few individuals, but for all; best for all, if all were to obey it.

The law is intimated to us by reason and the moral faculty, and the course of nature countenances and supports it. Reason, pondering all the phenomena, instructs us to revere the Deity; to exercise justice, candor and mercy towards our fellow-men; and to cherish temperance, fortitude, and diligence in our several avocations. But for the discovery of the great outlines of the will of God and duty of man, we are not left to the exercise of reason alone. Conscience, or the moral faculty, comes in to the aid of reason; and, by reason and conscience, all men perceive the great features of moral law.* Accordingly, there are certain dispositions and actions which have been always applauded or commended, and others which, as generally, have been the subjects of censure or detestation. All men approve of piety, benevolence, integrity, veracity, temperance, fortitude, industry; all men disapprove of contrary dispositions and conduct. Reason and the moral faculty may be perverted. This perversion, however, results from the abuse of free agency; and for it mankind have themselves to blame. Man is a free agent; but his body, his mind, and nature around him, are so constituted, that if he exercise his freedom in an irregular and capricious manner, in defiance of the dictates of reason and conscience, he must suffer a corresponding loss of happiness, or degree of pain.

3. Man, even in his present state, is happy or unhappy, rewarded or punished, as he obeys or disobeys the law. This is a demonstration of a moral government.

That the virtuous person, or he who performs his duty by obeying the will of God, enjoys much happiness; and that the vicious person, or he who lives in the habitual violation of the law intimated to him by reason and conscience, is subject to much infelicity, are truths so obvious, that they have not escaped observation in any age. All men, indeed, suffer a greater or less degree of uneasiness and pain; but the virtuous man experiences far less than the vicious. The first tastes all those joys which the moral constitution of his nature imparts: the last not only loses those joys, but suffers the miseries flowing from a disapproving mind.

There are sources of pleasure and pain common to us with the inferior animals, and consequently independent on moral conduct. Active exertion, animal gratification, worldly success, and the contemplation of some kinds of excellence, yield enjoyment both to good and bad men. Although the Deity has demonstrated his goodness by multiplying the sources of felicity, yet the purest and most constant stream flows into the bosom of the virtuous person. He who obeys the will of God has the fairest prospect of enjoying bodily health. If two persons, with constitutions equally sound, enter together on the career of life, and if one of them pursue a moral and the other an immoral course, it will appear, at no distant period, that moral conduct has the advantage in point of bodily health. The virtuous man also enjoys most peace of mind; and this peace of mind contributes, in no small degree, to health of body.

* By reason I understand the faculty by which we judge between truth and error, and combine means for the attainment of ends; by conscience, or the moral faculty, that by which we distinguish between right and wrong.

We are so constituted that reason and conscience not only indicate the will of God and the path of duty, but encourage and applaud us when we follow their direction, and disapprove and censure us when we pursue a contrary course. The good man, feeling the favor of God in the approbation of his own mind, looks forward with an humble and cheerful confidence to the future. There is no load on his breast, and he dreads no evil. But the bad man is often uneasy: he is haunted by remorse, and depressed and agitated by gloomy and painful anticipations. How soothing are the accents of an approving mind! What a sweet serenity, what a delightful complacency do they diffuse over the soul! On the other hand, the condemnation of reason and conscience is bitter as gall and wormwood. Under their censure and reproof we feel restless, mortified, and unhappy; and against the chidings of those internal monitors no bad man can at all times fortify himself. They are perpetual spies on his thoughts and actions, and their bitter reproaches will be as thorns in his pillow. No external circumstances can rob the good man of the exalted enjoyment flowing from the approbation of his own mind.

Obedience to the will of God is the surest way to obtain a competent portion of the good things of the world; for he who regulates his conduct by the law, is temperate and industrious, diligent in gaining and moderate in spending, and thus likely to enjoy a competency. I see no superstition in believing that the righteous Governor of the Universe, looking down with an eye of complacency on his dutiful children, may graciously crown their exertions with much success.

The good person also enjoys the esteem and affection of his fellow-men. Look at two individuals: the one is pious, upright, humane, temperate, and industrious; the other is irreligious, unjust, malignant, treacherous, indolent, and debauched. Which of these two would you choose for your friend? To which of them would you commit a trust? All men instantly, and with one voice, give the preference to the virtuous one. They esteem him; they love him; they wish him well. But the vicious person is the object of their contempt or detestation. Now, health of body, peace of mind, a competency of the good things of the world, and the esteem of mankind, are rewards which the righteous Sovereign, in the ordinary course of his government, bestows upon his obedient subjects. A diseased body, an unhappy mind, poverty, and contempt, are punishments inflicted on the disobedient. It is obvious that the natural course of things tends to the production of these effects; and if it be so, we are entitled to affirm, that the system of nature gives a sanction to the laws of the sovereign, and that a moral government is now carrying on. The instances in which such effects are not produced are exceedingly rare; and at these exceptions we need neither be surprised nor offended, in a vast scheme of free agency going on under the operation of general laws. Such exceptions are perfectly compatible with a state of trial and discipline, in which all our powers of body and mind must be improved and strengthened by exercise.

4. Exercise and trial are powerful means of improvement and sources of happiness; and a future retribution awaits us.

Man, as we have already seen, is a moral agent; and, generally speaking, he is happy or unhappy, as he obeys or disobeys the law intimated to him by reason and conscience. He is, at present, in a state of probation and discipline, under the eye of his Sovereign and Judge; and his improvement is carried on, and his happiness promoted by exercise and trial. We come into the world feeble in body and in mind, but with the seeds of improvement in both; and these seeds grow according to the cultivation they receive from exercise. The body grows in stature and in strength, and the mind gradually expands. But exercise is requisite to the development both of our corporeal and mental capacities. In the course of years, indeed, the body grows; but without exercise it is feeble and inactive; and the mind, wholly undisciplined, remains in a weak and infantile state. That exercise which is requisite, in order to bodily health and vigor, and to the evolution of our intellectual and moral powers, is not only the chief means of our improvement, but also the main source of our happiness. Without exercise of body and of mind there can be no enjoyment.

The constitution of nature and the government of the Creator are such as to call forth our bodily exertions, and to solicit and encourage the exercise of our intellectual and moral capacities. We are placed in circumstances calculated to awaken our faculties, to rouse activity, and to stimulate exertion. And man, when his powers are fully brought into action, can both do and suffer beyond what he would have previously imagined. He can pass triumphantly through scenes which, in anticipation, he would have thought overwhelming. Under these trials, if he act wisely, he makes the most rapid progress in improvement, and the retrospect yields him the most exalted enjoyment.

In all our conceptions, exertion is connected with success and renown. A triumph without an enemy combated and a victory won—a prize where no course is marked out, and no competitor starts with us in the race—are notions which do not find a ready admission into our minds. Such is our constitution, that, according to our usual train of thinking, where there is no exertion there can be neither honor nor reward. Progress in moral and intellectual excellence is our duty, our honor, and our interest. To be stationary or retrograde is disgraceful. In the progress of improvement, the present life soon comes to a close; but we are immortal beings, and we have reason to think that there is an intimate connect on between the present and the future. The whole of the Divine government, as exhibited in the course of nature, manifests a regard to piety, integrity, and sobriety; and an opposition to vice. The probability certainly is, that the great scheme, which is evidently going on at present, will be continued in a future state of being; and that they who have done their duty here, by employing their faculties and the talents intrusted to their care in conformity to the will of the Creator, as intimated in his works, and more clearly revealed in the Scriptures, and who have passed through their various trials with improvement, will, after death, enter on a nobler stage of existence, where they will still pursue the course of excellence; while they who have disregarded the intimations of reason and conscience, will suffer a corresponding loss.

CHAPTER VI.

EVIL IN THE WORLD.

From our inquiries in the foregoing part of this treatise, it appears that there is a Being all-powerful, wise, and good, by whom every thing exists. The existence of this Being is demonstrated by every part of the universe which we are capable of observing; for, throughout the immense field that lies within the limits of the telescope on the one hand, and of the microscope on the other, we every where meet with manifestations of contrivance, with mutual adaptations, and reciprocal dependencies; and by the constitution of our nature we are induced and constrained to believe in the existence of a designing and contriving mind, an essence in which perceptions meet, and from which volitions flow. It is obvious, that to this contriving mind we must attribute power, wisdom, and goodness, in the degree at least necessary for constructing and carrying on the great system of the universe; and we have seen that the manifestation of those perfections pervades the whole scheme of nature.

But do all appearances in the natural and moral world exactly correspond with this representation? Does every thing throughout the universe obviously harmonize with the belief of a God all-powerful, wise, and good? Are there no difficulties, no apparent inconsistencies, either in the natural or moral world? To such inquiries we may answer in general, that, in a system which we do not fully understand, it were unreasonable to expect that in every instance we should be able to give an explanation admitting of no doubt and of no reply.

From the phenomena of nature it clearly appears that the Deity is immeasurably exalted above us. We inhabit a small province in his boundless empire, forming perhaps a link in a mighty chain of intelligent being under him, and ought not to consider ourselves as a detached fragment of his works, but as a harmonious part of one great whole. His plan no doubt embraces the whole destiny of our race, from the beginning to the end of the world. The administration of such a scheme is too comprehensive to be understood by us in all its extent; and certain and perfect knowledge is by no means necessary to a moral agent. It is enough if we have such information as shall lay a rational foundation for the regulation of our conduct, for encouraging our hopes, awakening our ambition, and quickening our diligence. There is nothing unreasonable in supposing that there are higher created intelligences than we: they no doubt know more than we do; but it is likely that their knowledge of the universe and of the divine government is by no means perfect, and that the Author of the system is the only being who fully comprehends every part of it.

Difficulties which we are unable fully to solve may occur; but these difficulties, it is reasonable to think, arise solely from our ignorance and incapacity, and not from any imperfection in the works or government of God. Accordingly, the difficulties will appear more numerous or more formidable to some persons than to others. They will vanish in proportion as the light of knowledge increases, in the same way that darkness disappears before the rising sun. Beings of a higher order, of greater capacity, and more extensive knowledge than man, probably meet with fewer difficulties in tne works and government of God than we do, and perhaps not in the same instances. To a well-informed person, of a sound understanding, many things may appear plain and orderly, that seem dark and inconsistent to one of less knowledge and sagacity. In the progress of knowledge, those things which seem inexplicable to one generation may be well understood by another. We know more than they of past ages did; but still there are many things of which we are ignorant, and many things, perhaps, of which man will always remain ignorant. Of the cause of gravitation we know nothing. Why the magnet attracts iron, and, when allowed to move freely, turns itself towards the polar points, and why poles of the same name repel each other, we do not understand. Many things relating to electricity have hitherto escaped our research, and the operations of this substance on the great scale of nature we can neither fully estimate nor explain. Our knowledge of the works of the Creator is limited and partial, and that of his ways is not more perfect.

Even in these circumstances, however, we hold it to be a rational and edifying exercise to inquire into the attributes of Deity as manifested in his works and government; but our investigations ought to be conducted with reverence, and under a sense of the immeasurable distance between God and man. Many of the objections which have been urged against the wisdom and goodness of the Creator we can fully and fairly answer, and of others we can give a probable solution: but wisdom and goodness appear in so many instances, that it is not unreasonable to believe in their existence even when we are unable to trace them. What we purpose to say further on this subject will be arranged under the heads of Evils of Imperfection, Moral Evil, and Natural Evil. The first of these will not detain us long; but on the two last we intend to dwell at greater length.

I. EVILS OF IMPERFECTION.

Why was not man made so tall as to be capable of wading the ocean? Why has he not the strength of the elephant, and the piercing eye of the eagle? Why are not his intellectual faculties more powerful, so that his perceptions of truth might be more clear, and his conduct more regular? That the objections involved in such questions are absurd, can, I think, be plainly shown. This class of objections, in reality, precludes all gradation of being, for they may be urged against the existence of every creature. Why was not every clod of earth made a sentient being? Why was not every sentient being endued with reason? Why was not every rational nature adorned with all the attributes of Deity? Such is the extent of the objection, and its extent proves its absurdity; for absurd must every objection be which still remains in full force, what changes soever we suppose introduced in consistency with the notion of a Creator and creatures, of a Sovereign and subjects.

If it be alleged that this is straining the objection, which is meant to be applied to beings in certain circumstances only, then let the objector give a clear and consistent account of these circumstances. Let him determine the point beneath which sentient existence ought never to descend. Does he fix it at reason? Man possesses that faculty, and to his nature on that point no objection can be made. A gradation of creatures is unquestionably consistent with wisdom and goodness in the Deity; for, if a good objection lies against creatures occupying any one place in the scale, a similar objection may be urged against those occupying any other place in it. Is the capacity of happiness reckoned essential to sentient existence? It is evident that animals, under the guidance of instinct merely, are susceptible of much enjoyment. And do not irrational creatures, while enjoying much happiness themselves, contribute to the comfort and felicity of rational beings? This, I apprehend, cannot be denied. Unorganized matter nourishes vegetables. Vegetables feed many sentient beings. Vegetables and irrational animals support rational natures. In the gradation, the inferior ministers to the sustenance, improvement, or happiness of the superior parts. This process reaches as far as our observation extends. While the inferior are thus related to the superior parts in the scale, every class of sentient beings enjoys happiness in its own sphere.

The question is not whether we can conceive man to have been made a nobler being than he is. I perceive nothing unreasonable in believing that, in the multitude of worlds with which the universe is replenished, there are many creatures vastly superior to the human race. But the inquiry is, whether the constitution and circumstances of man, such as they are, be compatible with the existence of an all-powerful, wise, and good Being, the Creator and Governor of the universe. The discussion of this subject leads to the consideration of moral and natural evil, from which the most important difficulties respecting the perfections and government of God arise. Before entering upon these topics, we shall here state some facts or principles, which, although they have been already mentioned more or less diffusely, may be here repeated, in order that they may be more distinctly remembered.

1. Man is a free agent. If the Deity be possessed of all moral perfections, it must be agreeable to his nature to exercise a moral government. But the subjects of a moral government must be free agents; for a necessary agent is a mere machine, and is as unfit for being the subject of a moral government as a steam-engine or a wind-mill. Now, if it be consistent with wisdom and goodness to create free agents, and to place them under a moral government, then the consequences of free agency and moral government cannot be pleaded as objections against those attributes.

2. We are so constituted that our improvement and happiness are carried on and promoted by exercise, discipline, and trial. On this fact, however, I shall not at present dwell; for it has been already stated, and will be further illustrated in a subsequent part of the treatise.

These are unquestionably two great principles in the human constitution, and unless it can be shown that they are inconsistent with wisdom and goodness in the Deity, all objections against those attributes must be dissipated like smoke before the wind. The first of those principles accounts for the moral evil in the world; and the second throws light on the natural evils to which we are exposed, in cases which remain unexplained by the first.

In the course of this discussion, it must still be remembered that we are not to conceive of the Deity as a being of blind and indiscriminating benevolence, but as possessing all possible excellencies in the highest degree, and in a state of harmonious combination. He is not good only, but wise, and just, and faithful, and holy; and all those attributes act consistently with each other. We are also to remember that the evils in the world are comparatively rare and partial occurrences, spread over a large surface; sufficient to stimulate activity and encourage virtue, but, unless prodigiously increased by the abuse of free agency, are by no means so great or so numerous as to overwhelm our faculties or destroy our happiness. True, indeed, were we to collect all the variety of wickedness, suffering, and distress, from every period of time, and from every place in the world, and to present it in one unmingled assemblage, it would exhibit a fearful aggregate. But this aggregate would not be a picture of human life. It would not be a fair picture of the earth, to heap together all the volcanoes, naked rocks, sandy deserts, thorns, and briers, which occur on its surface. It would not be a fair representation of the animal world, to crowd together into one horrid spot all the serpents, and scorpions, and lions, and tigers of the earth. This were to collect in one point, and without mixture, what in nature is spread over a vast surface, and interspersed with large scenes of beauty, and copious sources of enjoyment. It were to represent what is uncommon and extraordinary, as if it were the universal state of the earth, and the common lot of man. It were like describing the sun as a mass of darkness, because black spots are at times discernible on its disk.

The evils that are in the world, in many instances, serve as the seasonings of life. They not only give a relish to its enjoyments, but they also promote the development of our faculties and the improvement of our virtues. And it is evident that, amidst all the vicissitudes of this chequered scene, man is more commonly in health than in sickness; his countenance is much more frequently enlightened by joy than clouded by sorrow.

II. MORAL EVIL.

The human body is a noble structure, indicating consummate wisdom and great goodness in the Architect; and it is a suitable temple for the residence of the mind. It is a material fabric, and consequently subject to the laws by which the material world is governed.

The mind, whether we contemplate it in a moral or intellectual point of view, is endued with high capacities. The understanding is susceptible of great improvement, and capable of splendid attainments. Complaints, however, against the moral constitution of our nature and the evils thence resulting, have been loud, by those who wish to devolve upon the Author of our being the blame of our own misconduct. But, whatever may be the cavils of the querimonious sophist, we are not cast as a wreck upon the moral ocean, without a pilot or a helm. Our Creator has graciously bestowed upon us a moral nature. He has with his own finger written the law of virtue upon our heart, and which the apostasy has not wholly effaced. Reason and conscience point out the path of duty and happiness; and they applaud and encourage us when we do well, and disapprove and censure us when we disobey their intimations. When we pursue an upright course, we feel complacency and elevation of soul arising from the approbation of our own mind. When conscience condemns us, we stand degraded in our own estimation.

All men commend the good and the virtuous. A pious, benevolent, equitable, industrious, temperate, and prudent person meets with general approbation, while one of a contrary character is as generally blamed. Besides, the constitution of the natural world supports our moral perceptions and judgments, tending to confer bodily health and a competency of the good things of life upon the virtuous man; while, from the moral constitution of our nature, he also enjoys peace of mind, and the respect and good-will of his fellow men. It is a law in the natural world that bodies tend towards the centre. It is, in like manner, a law in the moral world that virtue promotes happiness, and that vice is the parent of misery. If we were capable of taking a full and comprehensive survey of the government of the world, in all its bearings and relations, we would perceive that virtue as certainly tends to our welfare as the fruits of the earth to our physical comfort. According, then, to the moral and natural system of the world, the path of virtue is the road to happiness: the way of vice, how gay soever may be its decorations, conducts to the region of sorrow.

In opposition to what has now been said, it may be alleged that men differ in their moral perceptions and estimates; that what one people reckons blameless or praiseworthy, is condemned by another; and that the inhabitants of one country esteem honorable what, in a different nation, is thought degrading; that the Chinese expose their infants, and Indians knock their aged parents on the head, or leave them to starve in the wilderness; that a Georgian boasts of the number of public executioners that have been in his family, while, in Iceland, no person can be found to inflict a capital punishment.

To this we reply, that our moral powers, as well as our other faculties, may be misled and perverted. They are fitted to each other, and are equally susceptible of improvement or deterioration. Education, fashion, and habit, have a vast influence on our intellectual operations, and exercise a powerful sway over our moral judgments. But this does not disprove the moral constitution of man, nor establish any original difference of moral sentiment among different families of the human race, any more than an artificial difference in the figure of some parts of the body proves a different organization. On viewing the distorted cranium of some tribes of American Indians, or the small feet of the females in the Chinese empire, shall we maintain that nature has assigned no particular shape or size to the human head and feet? Because different nations entertain different opinions concerning the figure of the earth, or the motions of the solar system, shall we argue that reason is essentially different in the inhabitants of different nations, or that the figure of the earth, and the motions of the solar system, are merely ideal, and have no real existence? In like manner, on witnessing a difference of moral sentiment, shall we imagine that the Creator has bestowed no moral nature on man, or that there is an original difference in the moral constitution of human beings? No: both in the one case and in the other the peculiarity is a perversion. It is the triumph of bad education and vicious fashion over the appointment of the Creator. It is a deviation from the common character of the race, and has arisen from some particular combination of circumstances. And were we thoroughly acquainted with the peculiar circumstances of those nations among whom any singular moral perversity prevails, we would likely be able, in those circumstances, to trace the causes of the aberration. False moral judgments need not surprise us more than any other intellectual aberration.

While the law of virtue is engraved on our hearts, we are not compelled to obey it. Obedience is encouraged by many powerful motives, but it is not enforced by a mechanical or irresistible impulse. We are free agents; and beings of this description, although formed with an original bias towards rectitude, may abuse their liberty. If it be consistent with the attributes of Deity to create free agents, and to exercise a moral government over them, then neither the abuse of free agency nor the consequent suffering constitutes any objection against the Creator: blame attaches to the creature only.

On this subject, nothing comes fairly under discussion but the original constitution of the agent, and the circumstances in which he is placed. Now, the moral faculties of man are well adapted to his condition. They may yield to the temptations by which they are assailed, but are strong enough to repel those temptations, if we choose wisely to exercise them. Where there is no risk of failure, there is no honor in success: if our moral faculties had been so vigorous and active as to impel us in the right path, without any hazard of deviation, there would have been no value in moral rectitude. Such a constitution would not have been adapted to a state where the agents are to rise towards perfection, triumph, and safety, by steady perseverance, and vigorous exertion in a scene of discipline, difficulty, and trial.

As free agents may abuse their liberty, so, after moral evil is once introduced, it is continued and fostered by bad education, false maxims, and vicious example. Our Creator has endued us with noble capacities; but the evolution of those capacities and their particular direction are left to ourselves. By persevering discipline we can render the body capable of surprising operations, as is evident in the feats of the juggler, rope-dancer, and tumbler. The mind is still more completely subject to our dominion, and we may stamp upon it what impressions soever we please, almost with as much certainty as the Indian, by compression, gives to the head of his infant the shape which the fashion of his tribe dictates. Whether the moral germ, planted in our mind by the finger of the Creator, shall become a lovely plant, or a crooked and stunted shrub, depends on ourselves. We are empowered to be the architects of our character and the authors of our destiny.

By education and discipline we can form any particular temper, and give the empire of our mind to what dispositions soever we please. If we propose to ourselves a standard of conduct, we can regulate our actions by it. I do not mean to say that we can instantaneously form our temper and conduct according to a given model; but we can do so by degrees, particularly if the attempt be made in early years. Practice is the parent of habit. We cannot all at once become proficients in any bodily exercise or mechanical art. We cannot, on a sudden, give our mind the vigor requisite in order to high intellectual attainments, nor at once make ourselves masters of any particular science. But we can do so gradually, by exertion and persevering diligence. In the same way we can form our temper, discipline our affections and passions, and learn to regulate our conduct. If, with the proposed model always present to our imagination, we employ the same vigilant attention and persevering industry, we will be as successful in the one case as in the other. If a whole community combine their efforts in the same way, and emulously press towards the same point, the imitative propensities of our nature will greatly facilitate the process.

Nations are often distinguished by a peculiar character, which may be owing, in some measure, to external circumstances, but which is formed chiefly by education, fashion, and habit. A Turk and a Greek, born in the same climate, and inhabiting the same country, are very unlike in character. The Turk is grave and silent; the Greek volatile and talkative. Is not this difference entirely owing to education and habit? What a difference is there between the American Indian, chanting his death-song, and setting the cruelty of his enemies at defiance, and Patkul* on the wheel! Is not the sensibility of the Indian as great, and his sufferings as acute, as those of any other person in similar circumstances? Education, sentiment, and habit, however, have fortified his mind against the sense of pain and the fear of death.

That there is some original and inexplicable difference of constitution and temper, as well as of talents, among human beings, may be admitted. But, generally speaking, what is called *natural temper* is merely, I apprehend, a certain state of mind which indulgence has formed into habit. If we have a bad temper, it is because we have not been duly careful to form a good one. If unworthy passions predominate in our minds, it is because we have cherished them. If our conduct be incorrect, it is because we are not attentive in regulating it. When temper is very bad, all men condemn it. When actions proceed to a certain degree of enormity, human laws punish them. This condemnation and punishment show that, according to the general conviction of mankind, the temper might have been better, and the conduct refrained from; for, otherwise, neither blame nor punishment could with propriety follow. It may be pleaded, perhaps, that the passions gain strength sooner than reason, and that the character is, in a great measure, formed before the understanding is sufficiently matured to take any important part in the operation. But if reason be cherished as much as passion, their growth is more simultaneous than is commonly imagined. At any rate, reason, on attaining maturity, can correct temper, subdue passion, and regulate conduct.

Socrates was the most illustrious moral sage of the ancient heathen world. Zopyrus, an eminent physiognomist, on examining the countenance of the philosopher, pronounced him the slave of vicious passions. The friends of Socrates ridiculed the pretended skill of Zopyrus; but the son of Sophroniscus, with that candor and ingenuousness which formed such a prominent feature in his character, acknowledged that, in his early disposition, he was prone to vice; but that, by obeying the dictates of reason with persevering attention and exertion, he had overcome the worthless propensities which

* A Livonian, broken on the wheel and quartered at Casimir, 1707, by the order of Charles XII. of Sweden.

had once predominated in his mind, and given a cast to the lineaments of his countenance. Are we to neglect education, to cherish a bad temper and unworthy affections, to contract bad habits, and to persist in them, and then impute to our Creator the blame of our own misconduct? God has made us free agents; but at the same time he has endued us with reason and conscience for the government of our hearts and lives, so that the blame is entirely our own if we abandon the path of rectitude.

Besides, our Creator does not permit us to disobey the voice of reason and of conscience with impunity. His government is so constituted that the abuse of free agency is checked, not only by our moral nature, but by the natural evil which it introduces or increases. The waters of the ocean, although containing many corrupting substances, are preserved from putrefaction. The contamination of the atmosphere, by respiration and other causes, is not allowed to go on continually increasing: principles of counteraction and compensation are in continual activity. As it is in the natural, so it is in the moral world. The abuse of free agency is subject to checks, and is not permitted to exceed certain limits. Our moral faculties oppose its progress; and, if this opposition be borne down, an insuperable barrier at length presents itself in the accumulation of natural evil. Thus, by the constitution of nature, moral evil, after proceeding to a certain extent, is made, in some measure, to cure itself. When human affairs reach a certain point of perturbation, then, like the inequalities in the planetary system, they gradually return to the point from which they set off. They vibrate within certain limits. The accumulation of moral evil is wrought off like a scum from fermenting liquors. In the natural world, the tempest is a powerful means of purifying the atmosphere; an analogous scene presents itself to our view in the moral world.

The sufferings which result from the abuse of free agency are employed, by the wisdom and goodness of the Creator, not only as means of correcting our errors, but also of exercising our virtues, strengthening our faculties, and improving our nature. Suffering has a tendency to awaken our moral sensibilities, and to make us reflect seriously on our actions. If it be the means of bringing us to a due perception of our folly and guilt, of reclaiming us from error, and of leading us to a correct use of our freedom, we will again taste the sweets of virtue, and rejoice under the administration of a wise and benevolent Parent.

Suffering, in consequence of perverse affections and vicious conduct, may be considered as the kind castigation of a wise and affectionate father, to bring back his erring children to the path of duty and of happiness. In this point of view, the sufferings of moral agents are evidently consistent with the perfections and government of an infinitely wise and good Being. Indeed, in a great system of moral agency, the absence of suffering, except in cases where the agents have passed victoriously through a state of trial, and, by means of instruction, discipline, and practice, are confirmed in the habits of virtue, would constitute a more formidable objection against the perfections and government of God, than any that the atheist has been able to adduce. The parent who never chides or chastises, neglects the interest of his erring child; and were the universal Parent never to inflict chastisement upon the disobedient, this would furnish a presumption that he looked with an indifferent eye on the conduct of his rational offspring, and was careless about their moral improvement. But he takes a lively interest in the welfare of his children, and, by wise instruction and salutary discipline, restrains their wanderings, corrects their errors, encourages, exercises, and improves their virtues, and prepares them for a more exalted stage of existence; for associating with the numerous and chosen society of those who, having passed triumphantly through a course of trial, are confirmed in virtue, and far advanced in the perfection of their nature.

We often suffer from the abuse of free agency in others. Discord in families; jealousies, calumnies, envy, hatred, and mutual injuries among neighbors; and wars between nations, occasion the greater part of human misery, and may frequently involve us in trouble without any fault of our own.

In answer to this objection, we observe that the moral, as well as the natural world, is governed by general laws; and free agency can be limited only by the nature and abilities of the agents, subject to the counteraction of one another. In a great scheme of free agency, as in our world, the agents mutually operate upon, encourage and aid, or oppose, check, and restrain each other. Restraints by special interpositions of Deity are as inadmissible here as in the general laws of the natural world, and would produce similar injurious effects. No restraints can be imposed upon the agents, but such as arise from their physical and intellectual capacities, and the circumstances in which they are placed. It is the interest of all to regulate, direct, and keep within due bounds, the free agency of all; and to this common interest, in connection with our moral nature, the matter is left. I cannot conceive how it could be otherwise without the destruction of free agency.

"What, in the name of wonder," exclaims one, "can be the final cause of cruelty, slaughter, and devastation? Why should we be both able and willing to pervert the benevolent purposes of nature?" Might he not with equal propriety have asked, What is the final cause of lying, slander, theft, or any other action which proceeds from the abuse of free agency? Ought he not rather to have asked, What is the final cause of our being made free agents, creatures endued with freedom of will and liberty of choice, and not mere machines? For this is the point on which his questions ultimately bear. War, with its frightful concomitants, is a dreadful abuse of free agency, and ought not to be held up as a stain on the perfections or government of God, but as a melancholy instance of human perversity. If many suffer by war, many are guilty by aiding and abetting, or not opposing and counteracting that profligacy by which it is begun and carried on. Some, indeed, talk of wars as necessary, and seem to place them by the side of the volcano and the hurricane. But it is a monstrous absurdity to confound the guilt of the creature with the wise and gracious appointments of the Creator. Shall we vindicate murder by the plea that man is born to die, or defend the conduct of the incendiary because lightning sometimes sets our property on fire?

If, under the operation of general laws, we suffer from the abuse of free agency in others, without any fault of our own, this suffering exercises and improves our faculties, and gives scope for the development of virtuous dispositions and affections which otherwise would have lain dormant. If we meet with no rude treatment, we have no occasion for meekness and forbearance. Without injuries we have no room for the exercise of forgiveness. The sufferings which we endure from the misconduct of others, if we behave well under them, do not rob us of the approbation of our own mind, and consequently cannot deprive us of happiness. Our bearing them well, and our passing through the uncertainties, dangers, and trials of the present state with prudence and fortitude, are means for training us up in a meetness for a more excellent state of being.

Bad education, corrupt maxims, and vicious example, have a powerful and unhappy influence on human opinions and conduct. Bad government combines and aggravates all these causes of wickedness and misery, and has certainly been an abundant source of tribulation among men. These are adversaries with which we must strive in the moral course; enemies which we must combat and overcome in our moral warfare. And in order to success in the race and in the battle, it behoves us to use all the means in our power for the illumination of our understandings and regulation of our hearts; to form correct notions of duty and happiness; to cherish virtue in our minds, and with inflexible constancy to practise it in our lives.

The existence of moral evil forms no solid objection against the divine wisdom and goodness. It is not so predominant in the world as some gloomy theorists have represented; and with respect to that portion of it which really occurs, we can vindicate the perfections of Deity from every imputation. We are free agents—a condition necessary to moral government, virtue and vice, reward and punishment. We are endued with reason and conscience for the regulation of our conduct. Our temper and character are of our own formation. Our actions flow from our own free choice. If we follow a right course, we enjoy much happiness. If we act otherwise, we have ourselves to blame for the consequences; nay, the suffering which ensues is a kind warning that we have erred. The evils which we suffer from the misconduct of others, without any fault of our own, while they leave us in the full possession of the approbation of our own mind, give room for the improvement of our intellectual and moral nature. In the moral as in the natural world, partial evil is made subservient to general good.

III. NATURAL EVIL.

Having considered moral evil, we shall now turn our attention to natural evil; and shall arrange our thoughts on this part of the subject under the following heads:—

1. The physical constitution of the earth, and the quality of some of its productions.

2. The nature of some of the inferior animals.

3. The pains and sorrows to which man is unavoidably exposed from his very constitution, and the circumstances in which he is placed.

These topics open a large field, and will give room for a variety of observations. But before entering upon these things, we shall take notice of a principle of our nature, which has been already briefly mentioned, but which deserves a more particular attention; namely, its progressive capacity, together with the means by which, according to the constitution of things, that capacity is operated upon and unfolded. This seems to be a matter of considerable importance on the subject under discussion; and I shall, therefore, illustrate it at some length.

Every creature must be finite, and what is finite is susceptible of melioration. At what point soever in the scale of intellect any created being appears, there is room for progressive improvement. The being may advance from a lower to a higher degree of excellence. A progressive is nobler than a stationary creature. The latter, if any such exist in the rational universe, whatever may be his place in the scale, may ultimately be greatly surpassed by one who started from a much lower point, but who is endued with a progressive nature. The progressive principle pervades the system of the world. The early dawn gradually ushers in the morning light, which shines clearer and clearer till the meridian sun beams upon the earth. The seed germinates, and, by a gradual progress, the plant attains maturity. The noble oak springs from the humble acorn; but it must bear the chilling blast of many a winter before it lifts its head with majestic grandeur among the trees of the forest.

Animals of all kinds advance, some more rapidly, some more slowly, towards the perfection of their nature. The progress is still going on, although imperceptibly. The plant or the animal grows; but we cannot at any given moment discern its growth, and point out the increase it has received since the moment immediately preceding. This gradual and imperceptible progress takes place not only in plants and animals, but also in the rational nature of man, the only intelligence that falls under our observation. Every step in the progress prepares the way for that which is to follow. We have no reason to complain that we are children before we are men, for the exercises of our boyish years are needful to fit us for the duties of maturer life; and we have good reason to conclude, that the dispositions and habits formed and cherished by the active and virtuous discharge of the duties of the present life, educate and prepare us for entering into the enjoyment of a higher state of existence.

Our being endued with a capacity of progressive improvement is of itself a strong presumption of goodness in the Deity. If the means provided in nature for unfolding this capacity answer the end, God must be wise: in so far as we have pleasure in the use of these means, it demonstrates that he is benevolent. Now, we contend, that the means are adequate to the end, and, generally speaking, we have pleasure in the use of the means; consequently God is both wise and good. Even in those instances where we have no immediate pleasure in the means, nay, even where they give us pain, there is no proof of malevolence, because even these painful means are excitements to improvement and consequent happiness. They are often occasioned by our having been careless of the means of improvement. The schoolboy may dislike the discipline by which he is urged to his task; but if the ambition of excellence does not spur him on, other incitements must be applied. This, however, is no proof of malevolence in the teacher. We are impelled to the means of improvement by reward and punishment; happy when we use, unhappy when we neglect them.

The means provided in nature for the expansion of our capacities, both of body and mind, are adequate to the end. Exercise is the chief means of our improvement. It braces and invigorates the body; it unfolds and strengthens the powers of the mind; and to exercise we are prompted both by the constitution of our nature, and the circumstances in which we are placed. Like Sisyphus, we must roll our stone; but we do not, like Sisyphus, roll it in vain. By every wise and vigorous exertion we rise in excellence, and never lose ground but by folly, carelessness, or sloth. Within certain limits, the vigor of our faculties increases in proportion to the employment which we give them.

Bodily exertion renders the whole frame active, robust, and hardy; and any particular member of the body, or organ of sense, that is much employed, acquires a corresponding degree of strength and dexterity in the peculiar manner of its application. Those persons who bear on their backs the produce of the Mexican mines exhibit a robust appearance. The diminutive Bosjesman* bounds over the mountains with the agility of a roe. The American savage discerns the footsteps of his friend or of his enemy, where a European eye does not perceive any vestige. The mariner descries a ship at sea, where a stranger to maritime life cannot behold a speck in the distant horizon. The Bedouin Arab,† who, after sweeping the view with his eye, alights from his horse, and applies his ear to the ground, listening for the tread of the distant traveller of the desert, catches the sound which entirely escapes one unpractised in his manner of life. A

* Bosjesmen or Bushmen, a tribe of Hottentots.

† Bedouins or Bedoweens, a numerous Mohammedan race, in the deserts of Arabia, Egypt, and Northern Africa.

blind person has been seen to walk the streets of a town, and turn every corner with the utmost precision; and in some blind persons, the sense of feeling has become so delicate as to enable them to distinguish cloths of different colors, and even in cloth of mixed colors to ascertain the particulars. The senses of smell and taste are equally susceptible of improvement.

Practice is the parent of dexterity in any manual operation, as is evident in all the mechanical arts. It likewise improves skill in the conduct of any difficult enterprise. An American Indian will safely shoot a rapid in his canoe, or steer his frail bark in the tempestuous ocean, where the most experienced European seaman would perish. As the body is braced by labor, the organs of sense meliorated by careful application, and manual dexterity acquired by practice, so the mind is improved and strengthened by the exercise of its faculties. Ingenuity is sharpened by the occasions which call it forth. By being brought into action, our mental powers acquire an increase of strength and modification of habit. Every faculty, judgment, memory, or imagination, is improved, according to the exercise which we give it. The tool with which I perform any manual labor wears away in the operation. The axe and the saw become blunt; and, by frequent attrition, the substance of the ploughshare and of the spade is gradually diminished; but the hand of the laborer hardens, and accommodates itself to his work, while his arm waxes stronger by employment. The mind, if allowed to slumber in drowsy indolence, becomes feeble and palsied; but call it into action, and its dormant powers are awakened. When employed on external objects, it operates beneficially on itself, for its capacities expand; and, like a plant under the genial influence of the solar beam, all its powers are unfolded. Both body and mind bear a resemblance to the magnet, which, by gradual additions, may be made to bear a weight which, at first, it was utterly incapable of supporting.

All our pleasures have a close connection with the exercise of our bodily and mental powers; and one outward situation is more favorable to happiness than another only in proportion as it gives opportunities for a more varied and unconstrained exertion of them. The love of exercise plainly appears in the inferior animals. Lambs running and gamboling round a hillock; horses scouring the plain; dogs keenly pursuing each other; and even the timid hares sporting together, are proofs that the felicity of the animated being does not consist in motionless repose and inactive gratification.

We see children actively employed in their amusements. They delight in the exercise of their limbs; and that exercise preserves their health and promotes their growth. Happiness is not found on a bed of down, nor in a state of listless sloth and luxurious gratification. Cheerless languor, lingering disease, and early death, are the common lot of wealthy indolence. But the person who labors diligently for his daily bread, is in general healthy, cheerful, and contented.

It is a common law of our nature, that what costs little exertion imparts little pleasure; what is obtained without labor or expense is possessed without enjoyment. He who gains a fortune by his own industry, feels a relish in the possession of it, to which he who succeeds to a similar fortune, without industry, is a stranger. Indeed, there is often more pleasure in pursuit than in possession, in hope than in enjoyment, in labor than in reward. Many things are valued chiefly on account of the pleasure which the pursuit affords. Game is hunted not so much for its intrinsic worth as for the gratification of the chase.

The mind of man has no pleasure in unvarying rest. Its enjoyment springs from action. Hence men in every rank, and in every stage of society, devise employment for themselves, if it be not imposed upon them by necessity. The South Sea islander exercises and amuses himself by sporting among the breakers like a walrus. The North American Indians, in the vicinity of the Athapuscow and Slave lakes, instead of enjoying all that rest and ease of which their circumstances admit, court exercise and employment at the expense of severe privation and great danger. They can easily find a plentiful subsistence for their families during winter, by catching deer in a pound; but only the aged and infirm, the women and children, and a few of the more indolent and unambitious, will submit to remain in the parts where food and clothing can be so easily procured. To this they prefer the uncertainty, fatigue, privations, and dangers of the chase, and of a wandering life. "In my opinion," says the hardy traveller who states the fact, "there cannot exist a stronger proof that man was not created to enjoy happiness in this world, than the conduct of those miserable beings who inhabit this wretched part of it." Here we have an example of the incorrect thinking not unfrequently entertained by persons whose lives are more devoted to action than contemplation; for the opinion rests on the supposition, that happiness consists in undisturbed repose, and in the enjoyment of unsolicited abundance. But in a state of unvarying ease and spontaneous plenty it does not consist; it is in earnest pursuit and vigorous exertion that the energies of the human being are unfolded; and in them is his happiness obtained. The hunter is pursuing and enjoying pleasure amidst the fatigues of the chase and the perils of the wilderness.

In civilized society, the opulent, who are under no necessity of earning their means of subsistence by daily exertion, find employment for themselves by engaging in hunting, or in other similar occupations. The man of science and liberal curiosity renounces literary ease and domestic comfort, traverses the globe, mingles with savage tribes, ascends the Alps or the Andes, encounters the cold and storms of polar regions, or visits the crater of Ætna or Hecla. Our most exalted pleasures flow from successful exertions of intellect. What sensual gratification deserves, for a moment, to be compared with the joy of Pythagoras, on discovering that the square of the hypothenuse is equal to the squares of the other two sides of the right-angled triangle?—with the transport of Archimedes, when he sprung out of the bath, exclaiming, "I have found it!" on discovering a method by which he could ascertain the quantity of silver which a goldsmith had put into Hiero's crown? or with the ecstasy of Franklin, when he perceived the fibres of the cord attached to his kite exhibiting signs of electricity? These are the most sublime enjoyments of which man, in his present state, is susceptible; and all these advantages, which we gain by skill, industry, and virtue, give us high pleasure on reflection. Thus exercise is the chief means of our improvement and happiness; and to exercise we are impelled, not only by the constitution of our nature, but also by the circumstances in which we are placed. Our constitution and circumstances are as much adapted to each other as the wing of the bird and the atmosphere; the gills of the fish and water. Here we have a striking instance of that relation of one thing to another which pervades the universe, and which demonstrates unity of plan and skilful contrivance in its formation.

Had we been set down in a situation where every want was at once supplied, every wish and desire gratified without difficulty or delay, and where there was no room for ingenious contrivance and active exertion, we should have been the miserable victims of languor and satiety. Without something to awaken fear, encourage hope, and stimulate activity, life stagnates in stupid torpitude and melancholy indolence. But nature around us is admirably fitted to rouse activity, encourage ingenuity, and reward industrious exertion. Every thing conspires to animate our diligence, to improve our talents, and to promote our happiness. The earth is wisely accommodated to our active and intelligent nature, for its bowels as well as its surface administer to our comfort; and every part of nature around us may be made to increase and diversify our enjoyments, according to our circumstances and tastes.

There is no danger that the means of employing either our bodily or intellectual powers will ever be exhausted. To cultivate the earth, drain the marsh, straighten the water-course, and embank the river; to form roads and bridges, and to carry on the various branches of manufacture and commerce, will still furnish abundant scope for human industry. There will also be an ample field for the operations of intellect in the progress of science; for although our present attainments are great, yet the next generation will find enough to exercise their ingenuity. Every step we advance in knowledge enlarges our views, and opens new subjects of investigation and discovery. It is like travelling in a winding and interminable valley, bounded on each side by woods and mountains. At each bend, where we expected to find its termination, we perceive that the scene is only varied, and new prospects disclosed to our view. Notwithstanding all the industry, skill, and discoveries of Davy, there still remains abundance of room for laborers in the same field; to trace matter to its elementary forms, and through its various combinations. Newton improved on the discoveries of Kepler* and Galileo.† La Place has executed what Newton left undone; but there is still room for adding to the sublime discoveries of La Grange‡ and La Place. The intellectual hero will never need to sit down and weep because he has conquered the world of science, and exhausted the mines of discovery. To a person of determined and persevering industry, to whom

* A German astronomer of high celebrity, the friend and companion of Tycho Brahé, and highly commended by Des Cartes, Newton, and others. He was the first who proved that the orbits of the planets are elliptical, instead of spherical, as was then believed; and that, in their motions, they describe equal areas in equal times, and that the squares of their periodical times are equal to the cubes of their distances. Yet he held to strange absurdities; among others, that the earth has a sympathy with the heavens, and that the globe is a huge animal, which exhales the winds through the crevices of the mountains, as through its mouth and nostrils! He died at Ratisbon, 1630, æt. 57.

† A celebrated astronomer and mathematician of Florence. He first discovered mountains in the moon, four of Jupiter's satellites, and the Medicean stars. He invented the cycloid, and observed the increasing velocity of the descent of bodies. He suffered greatly from the inquisition, and died 1642, æt. 78.

‡ A mathematician of Turin. To him we are indebted for many important discoveries respecting the motion of fluids, and the theory of vibrations. He died, 1813, at Paris, æt. 77.

no labor is irksome, and no difficulty appears insurmountable; to him no enterprise is too great, and no attainment hopeless; no department in science, and no discovery in nature, is above his reach.

We may further remark, that employment is an advantage to our moral as well as to our intellectual nature. It is a powerfnl preventive of temptation; for he who has nothing to do has much need to be confirmed in virtue. Such, then, is our active nature, and such the circumstances in which we are placed. In so far as these circumstances are fitted to exercise and develop our powers, they may fairly be adduced as evidences of wisdom; and if we have enjoyment in the exercises to which our nature and circumstances prompt us, the Author of the system must be benevolent.

I now proceed to the consideration of natural evil, under the several heads already mentioned, namely, the physical constitution of the earth; the nature of some of the inferior animals; and the pains and sorrows to which man is liable.

1. The physical constitution of the earth.

Some have objected to the general appearance of the earth, representing it as a shapeless mass, without order or beauty; inundated by the ocean, disfigured by ragged promontories and irregular indentations; the dry land deformed by mountains and morasses; occupied by lakes or deserts; yielding poisonous plants and minerals; in one quarter parched by the beams of a vertical sun, and in another bound up in chains of everlasting ice. Such representations, at first sight, have an imposing appearance, and, when expressed in pompous language, may please the ear, and have no small tendency to mislead the imagination. But, on a closer inspection, those apparently mighty difficulties in a great measure disappear; and the due consideration of them teaches us a lesson of caution and humility when examining the works of the Almighty. It teaches us not to be hasty in supposing that improvement would follow a change in any of the great conditions of nature; for such a change, it is likely, instead of improving the world, would break the harmony of its parts, and destroy the symmetry and use of the whole.

That the earth bears marks of having undergone some great convulsion, is not denied; but we do not admit that from this any inference can be drawn against the perfections or government of Deity; for the earth, as it presently appears, is a convenient habitation for man and for the inferior animals. These animals all find subsistence. With respect to man, every thing around him is fitted for supplying his wants, and for promoting his enjoyments, by calling forth his activity and by giving scope to his exertions. Every thing is adapted to his physical and intellectual constitution, and is suited to preserve his health, to brace his body, and to invigorate his mind.

The great extent of the ocean, in the estimation of some persons, is a mark of imperfection. And on this subject let us listen to the complaints of the atheist, and call in his wisdom to remedy the evil. Let us empower him to dry up the waters, and to reveal the deep channels of the ocean; yea, if he will, to elevate the bottom of the sea to a level with the adjacent land, and to give the earth the exact convexity of an artificial globe. He has remedied what he thought a defect; he has introduced beauty where, in his imagination, deformity prevailed. What is the effect of his supposed improvement? By one great operation he has destroyed a vast number and variety of sentient beings, which dwelt in the ocean and enjoyed happiness. He has also laid the sure foundation for the speedy extinction of animal and vegetable existence; for if there be no ocean, the sun will exhale no vapors; no clouds will float on the atmosphere, and neither dew nor rain will descend on the earth. But if there be no dew and no rain, where shall we find the aliment of vegetation; the murmuring brook and the majestic river? Experience teaches us that without springs and rivers there is no fertility; and, consequently, without them man and beast must expire, and lifeless stillness and sterility take possession of the vast desert. Such are the effects of atheistical wisdom and improvement. Before any complain of the extent of the ocean on the terraqueous globe, let them show that a less surface of water would equally well answer all the purposes served by the sea. This, we may without hesitation affirm, they can never do. We may, therefore, dismiss their complaints on this subject, as the offspring of ignorance and folly.

The ocean is a vast field of enjoyment to sentient beings, and it yields inexhaustible treasures to the human race. If we look to the two extremities of the American continent, we see, at the one, the wandering savage of Terra del Fuego devouring fish; and, at the other, the Esquimaux spearing salmon in the Copper Mine River. Although many of the human race draw a considerable portion of their subsistence from the deep, yet this great storehouse has, perhaps, never hitherto been turned to the best account by civilized nations. The sea also facilitates the intercourse of nations, and harmonizes with the whole system of nature, in presenting a scene fitted to awaken the energy, and to give employment to the activity and enterprise of man.

The ocean is preserved at a moderate temperature by the statical principle by which the heavier columns of a fluid displace the lighter; and, consequently, it tends to modify the temperature of the land. For the temperature of the ocean communicates itself to the superincumbent atmosphere on every side; and, in this way, the sea cools the land in tropical climates, and increases the temperature in high latitudes. How refreshing is the sea breeze to one panting under a vertical sun! And do not the insular inhabitants of high latitudes enjoy in winter a milder atmosphere than they who dwell on great continents under the same parallel?

Humboldt has observed that the interior provinces of America, between 30° and 38° north latitude, like the rest of North America, have a climate essentially different from that of the same parallels on the old continent. A remarkable inequality prevails between the temperature of the different seasons. German winters succeed to Neapolitan and Sicilian summers. This is, no doubt, partly owing to the configuration of the land and the course of the mountains; but a grand cause of it seems to be the breadth of the continent, and its prolongation towards the north pole; for great and unbroken continents are favorable to the extremes of heat or cold, because the surface of the land is heated or cooled sooner than the water. This principle may be applied in explanation of the fact that, in proceeding eastward from the shores of the Atlantic, through Europe and the north of Asia, the temperature of any parallel of latitude still becomes lower as we advance. The ocean, then, is a great source of animal enjoyment. It is of essential importance to our world; and we have no reason to conclude that a less basin of water would answer all the purposes in the economy of nature. The deep indentations of bays and gulfs are highly useful for commercial purposes; and they also contribute to supply the wants of man, by bringing the stores of the sea into the bosom of the land.

Some complain that the surface of the earth is broken down into many inequalities, rugged mountains, deep valleys, and morasses. But this constitution of things, instead of being a just ground of complaint, serves many valuable purposes. It gives the productions of different climates under the same latitude; furnishes a residence and food for different kinds of animated beings, is a powerful means of clothing the earth with beauty and fertility; and gives scope to the ingenuity and exertions of man. In ascending the Andes, for instance, at different points above the level of the sea, we meet with the productions of equatorial and polar regions, and of all the intermediate climates. In Mexico, the same parallel of latitude produces the banana, the apple, the sugar-cane, wheat, the manioc, and potato. There the nutritive gramina, which vegetate among the ices of Norway and Siberia, cover the fields of the torrid zone. There the oak grows only at an elevation above the level of the sea of between 2500 and 10,000 feet: the pine never descends farther down towards the coast of Vera Cruz than to about 6000 feet above the level of the sea, and is never found higher in the mountains than about 13,000 feet. The wheat of Europe occupies a belt on the declivities of those mountains, between about 4500 and 10,000 of elevation; the banana-tree, the fruit of which constitutes so much of the food of the inhabitants of many tropical regions, scarcely bears any fruit at a higher elevation than 5000 feet above the level of the sea. Some plants live only in cold and mountainous places; and it were vain to look for them but in regions bordering on everlasting snow.

Although many mountains do not rise to the height of those now referred to, yet, in their several degrees, they yield nourishment to a proportional diversity of plants. If it be alleged that this can hold true of mountains in tropical or temperate regions only, it may be remarked that the height of mountains diminishes as we advance from the equator towards the pole. Chimborazo, at the equator, is about 20,000 feet high: the mountains of Iceland, on the confines of the Arctic circle, are not above a fourth or fifth part of that height.

The variety of mountains and valleys furnishes different kinds of animals with a residence and food suited to their natures. The ox delights in the plain, as there he finds the food which to him is most palatable. Sheep prefer the naked hill, because their beloved *festuca* grows there. Goats climb the precipice to browse on tender shrubs; and, by their agility and the structure of their feet, they are well qualified for springing from crag to crag. The argali, or wild sheep, and some of the deer kind, give the preference to the bare mountain. In warm climates, high mountains, by means of the ice and snow with which they are perpetually clothed, lower the temperature of the neighboring plains. The towering Andes cool the contiguous countries, and the mountains of Thibet render the spreading plains of Hindostan habitable.* Mountains also modify and direct the course of the winds, and shelter the low lands from the blast. To mountains the plain is indebted for its beauty and fertility. They attract the clouds, condense the vapors, are the sources of streams and rivers, and convey a fructifying moisture to the valley and the plain.

Ray,† in his valuable work on "the Wisdom of God in Creation," distinctly states the fact, that more water is exhaled from the sea in vapor than is returned to it in rain; but for the fact he is at a loss to account. "Why," says he, "should not the winds carry the vapors that are exhaled out of the earth, down to the sea, as well as bring them up upon the earth which are raised from the sea? Or, which is all one, why should not the wind blow indifferently from sea and land? To which I answer, that I must needs acknowledge myself not to comprehend the reason hereof." In explanation of the fact, for which this well-informed writer did not attempt to account, we may observe, first, that the surface of the land is more easily heated than the sea, consequently the wind blows from the sea towards the land to restore the equilibrium, and carries the vapors along with it: secondly, mountains attract the clouds, stop them in their course, and make them pour down their contents on the earth. These two observations go far to explain the fact that more rain falls on the dry land than is exhaled from it; and they tend to show the utility of mountains.

If we trace the course of any great river, it conducts us to mountains. The Orinoco and the De la Plata lead us to the Andes. The Mississippi and the St. Lawrence have their sources in an elevated region; and a mountainous ridge separates the basin of the Columbia from the waters of the Missouri. The Alps send forth the Danube and the Rhine, the Rhone and the Po. The vapors exhaled from the Mediterranean pass over Egypt almost without dispensing a single shower; but the lofty mountains in Abyssinia arrest them in their course, and rob them of their treasures. The Nile, spreading fertility over its banks, conveys the swelling waters to the Mediterranean. Thus the mountains of Abyssinia, lying in about 12° N. latitude, are the means of clothing the

* Under the equator, the region of perpetual snow commences at an elevation of 15,750 feet: in 45° N. lat. it commences at 8350 feet.

† Ray, or Wray, an eminent English naturalist, fellow of Trinity College, Cambridge. He devoted himself to botany and the universal history of nature. He was characterized by a strong benevolence of heart, humility of mind, and modesty of manners. His works are very voluminous, and the one referred to in the text particularly valuable.

Thebais and Delta, from 24° to 31°, with beauty and abundance. Without the mountains of Abyssinia the valley of Egypt would remain an arid and inhospitable desert. We might run over the globe, and every where we would find mountains of essential benefit to the earth. While they attract the clouds, their structure is such as to retain much of their water, and to give it out in perennial streams.

Mountains contain iron, copper, lead, and many other mineral substances of indispensable utility to agriculture and the arts; and although to some they may appear marks of irregularity and deformity, they are nevertheless the perfection of order, and essential to the beauty and fertility of the earth. Without them we can have no magnificent or pleasing scenery. They afford a commodious residence or a safe retreat to many of the inferior animals, and they diversify, adorn, and enrich the prospect to man. While so extensively beneficial, they do not so much affect the sphericity of the earth, as a few grains of sand, scattered on the surface of an eighteen inch globe, affect its sphericity. For the diameter of the earth is nearly 8000 miles; and the top even of Chimborazo, the loftiest peak on our globe, is only about four miles above the level of the sea.*

As mountains contribute to the beauty and fertility of the earth, so to drain the morass, and convert the quaggy swamp into a beautiful and fertile field, exercises the ingenuity and employs the activity of man. The mountain is essential to our subsistence; the marsh contributes to the development of our powers. The materials of subsistence and comfort are spread plentifully around us; but they do not drop into the lap of drowsy indolence and lumpish inactivity. In order to obtain them, we must exert our powers both of body and mind. We must cultivate the earth, cut down the forest, drain the bog, straighten the water-course, and apply proper manure to the soil. By the diligent and skilful exertion of our powers and application of our means, we can produce mighty changes on every thing around us, and make the influence of our operations be felt even on those parts of nature which, at first sight, seem entirely above our reach. We can in some measure disarm the elements of their rigor, and improve the climate as well as the soil by cultivation; by draining marshes and lessening evaporation, which carries off a quantity of caloric, and occasions a corresponding de-

* The Himalaya mountains have been estimated at about 27,000 feet; but their height is not yet well ascertained.

gree of cold; by turning up the soil and exposing it to the rays of the sun; and by thinning and cutting down forests, which by their shade exclude the solar beam from the earth.

The barrenness of many parts of the earth has been the theme of discontented declamation, and has been plausibly urged as an objection against the wisdom and goodness of Deity: like other objections, however, it is deceitful, and more showy than solid. Men have agreed to give the character of fertility to the soils which are favorable to the production of a few kinds of farinaceous grains, and to pronounce others barren and unfruitful. But many seeds, plants, and herbs, require a peculiar soil and climate to bring them to maturity, and the soil to which the character of fertility has been attached answers for a few only. The fact has been known since the days of Theophrastus, and is mentioned in the pleasing verse of Virgil. The willow thrives in a moist soil; the alder, in marshes; the wild ash, on the rocky mountain; the vine, on the open hill; the yew, in a moist and elevated situation. When mahogany grows in a barren soil, the grain of the wood is beautifully variegated; on rich soil, it is pale, open, and of little value. The cinnamon-tree thrives amidst arid sands. There are plants suited to every soil. Even the trunks of trees and stones are covered with various kinds of liverwort.

Grasses are the most useful, and also the most common, of all vegetables. They clothe the mountain and adorn the plain; they vegetate luxuriantly within the tropics, and in the summer months beautify and enrich the polar regions. The cereal grasses yield a rich nutriment to man; and many grasses, which every where cover the earth with spontaneous verdure, afford a suitable provision to the brute creation. Those grasses, herbs, and shrubs, which are rejected by one class of animals, are greedily eaten by another. As there is a vast variety of plants, many of which require both a peculiar climate and soil to bring them to perfection, so the wise and gracious Creator has provided a suitable climate and soil for plants of every kind. Animals have different tastes; and their diffusion over the earth is promoted by these tastes, as well as by a corresponding variety of plants. And certainly it is a matter of no small moment, that the climate which suits the constitution of the animal, also produces the food which to it is most palatable.

Even supposing any spot so barren and miserable as to afford neither subsistence nor shelter to any sentient being, this would furnish no other argument against the perfections of

Deity than what would arise from a diminution of the surface of the earth. It would be merely so much of the globe withdrawn from the immediate use and service of living creatures. But we have no evidence that any part of the earth is so withdrawn. The poles are encompassed with a great barrier of ice: as far, however, as man has been able to penetrate towards them, the water abounds with inhabitants, some of which occasionally repair to the ice. In Nova Zembla there is no human habitation; but there foxes and bears find a place of residence and a scene of enjoyment. The ostrich delights in the burning sandy wilderness.

From the nature of the soil and the inconstancy of the elements, the crops at times may be deficient; but, in every case of famine, there is either a neglect or misapplication of our means, and of our physical and intellectual powers, or an abuse somewhere of free agency; for, with diligence and precaution, even the chill Icelander may always secure the means of subsistence either from his native soil and circumambient seas, or by commercial intercourse with foreign lands. And even within the tropics, and in the most fertile regions, when industry lifts a palsied hand and cultivation is neglected, scarcity and famine are not unknown. When the distant supplies which prudence and industry have provided are intercepted by hostile violence, there is an abuse of free agency; and, in a system carried on by the operation of general laws, this abuse at times may be severely felt even by the harmless and unoffending.

Some have complained of poisonous herbs and minerals. Poison, however, is merely a relative term. No plant, I believe, is absolutely destructive of animal life. Those vegetables which are disagreeable or poisonous to one class of living creatures, are grateful and nourishing to another. The horse gives up the common water hemlock to the goat; the goat leaves monkshood to the horse. Even wormwood and the acrid spurge yield an agreeable repast to some kinds of insects. The inferior animals are guarded against danger from what they eat by an instinctive delicacy of smell and taste. Man, at least after he has acquired an artificial taste by means of cookery, must exercise vigilance and sagacity; although his smell and taste, unless greatly perverted, will seldom or never mislead him. Even from those vegetables which are most destructive of human life, we can extract a salutary nutriment or a healing virtue.

Some plants we can disarm of their poisonous qualities, and convert into materials of wholesome aliment. The bitter jatropha is an active poison. The natives of Haiti, who preferred death to involuntary labor, killed themselves by fifties with swallowing the raw juice of the plant. But even the juice of the bitter jatropha is rendered harmless by boiling and skimming, and is then used without danger as a sauce. The root is also baked into bread; but, in order to deprive it of its noxious qualities, it must be grated down and compressed. The empyreumatic oil of tobacco is an active poison. But tobacco in a variety of ways is advantageously used. It is even employed as a remedy against other poisons. "The Caraibs,"* says Humboldt,† "used mashed tobacco leaves as a counter poison. In our journey on the Orinoco, we saw mashed tobacco successfully applied to the bite of venomous serpents." Foxglove, hemlock, poppy, and other similar plants, have each medicinal virtues.

We may remark, that different parts of the same plant, in many instances, have different qualities; and the same may be said of plants in their different stages. Different plants elaborate different juices from the same soil; and different animals elaborate different substances from the same plant. Bees form honey from thyme and roses; and from the same plant spiders draw a poison. From vegetables, innocuous and agreeable, a deleterious substance may be extracted. The laurel is pleasing, the almond beautiful and nutritive; but the laurel and the bitter almond yield most powerful poisons.

Minerals do not constitute any part of human food, but they are of vast importance in the arts; and their value in the arts not unfrequently depends on those very qualities which render them destructive when taken into the stomach. Only a few are poisonous; and most, or all, even of these, are serviceable in medicine. Arsenic itself is employed with advantage in the healing art. In short, the constitution of the vegetable and mineral kingdoms, like every thing else in the world, is adapted to the rational, active, and progressive nature of man. The existence of poisonous substances serves to awaken his vigilance, and exercise his sagacity; and we may safely conclude, that there are neither plants nor minerals but what have been, or may be, turned to his advantage. The discovery of their qualities and uses exercises his inge-

A tribe of the aborigines of some of the Caribbee Islands—a ferocious and invincible race.

† A scientific and adventurous traveller. The Voyage of Humboldt and Bonpland, published in 1810 (12 vols. 4to.), is a work of great extent and richness, to which the modern literature of Europe can hardly offer a parallel.

nuity; the application of them administers to his comfort, and diversifies his enjoyments. The discoveries which may yet be made in the progress of science, and the consequent advantages, we are unable to anticipate.

On the surface of the earth there are very different climates; and if it could be demonstrated that this could originate in nothing but a defect of power, wisdom, or goodness, then we would be compelled to admit that such defect adhered to the Author of the system; for difference of climate is part of the plan in the constitution of our globe. Towards the equator the heat is always considerable, except at great heights above the level of the sea: as we approach the poles, generally speaking, the cold increases. The climate of a country, however, does not depend altogether on its latitude, but also on its elevation above the level of the sea, its contiguity to the ocean, the configuration of the land, and a number of other local circumstances. The temperature of the earth varies from about 100° to —40° Fahrenheit: the mean temperature for the whole surface may be estimated at 58°: the greatest summer heat is only about 42° above this: the greatest winter cold is about 98° under it. The temperature of man is about 96°, and is nearly the same in summer and winter, in an inhabitant of the torrid, and in one of the frigid zone. The temperature of the human body is much above that of the surrounding medium.

In the different climates there is no defect either of wisdom or goodness: they exhibit a display of those attributes by opening a field of enjoyment to a greater variety of sentient beings. Both in the sea and on the dry land there are animals peculiar to certain climates. Some fishes are found chiefly within the tropics; others have their residence in polar regions. A similar economy prevails on the dry land. Many animals, such as the monkey and the elephant, are natives of warm climates, and there they find that sort of provision for which they have the greatest relish: others, such as the rein-deer, delight in high latitudes; and there they find the food which to them is most palatable.

While many of the inferior animals are fitted, by their peculiar constitution, for living comfortably in one climate only, man is endowed with a flexibility of organization which enables him to bear the temperature of every country. He can accommodate his dress to the climate, and can live, perhaps with equal degrees of happiness, in every parallel of latitude between Cape Horn and Greenland. Every where his intellectual and moral nature is equally susceptible of improvement. The Icelander, touching the Arctic circle, is as intelligent, virtuous, and happy, as the native of any country between the tropics.

Man is so constituted, that habit produces great effects both on his body and mind; fortifying the one against fatigue and privations, the rigor of the seasons, and the most rapid transitions from one degree of temperature to another; and not only reconciling the other to various modes of life, but even rendering these agreeable and pleasant. The Finlander amuses himself, for half an hour or an hour, in a bath heated to 150° or 160° Fahr.; and frequently goes naked out of the bath to roll himself among the snow, when the mercury stands at 20° below the freezing point. From this great and sudden transition he receives no injury. It has been found that persons accustomed to attend an oven, have borne for ten minutes a heat equal to 280° Fahr. In common cases, suffocation begins to takes place in about half a minute after the body is submersed in water; but the divers in the pearl fishery can remain under water five minutes, almost as long as the seal, porpoise, and amphibia. The dexterity of the South Sea Islanders in swimming is well known.

We are apt to set up our adventitious tastes and habits, sentiments and employments, as the standard of excellence and measure of comfort, and to imagine that those things only, which are sources of enjoyment to us, can yield satisfaction and happiness to others; and that what is disagreeable or painful to us, must be equally so to all our fellow men. The native of a tropical country may imagine that the inhabitants of polar regions are a torpid, hungry, and miserable race; but they who dwell in high latitudes are not less active, cheerful, or vigorous, than they who bask in the rays of a vertical sun. The delicate European may shudder on seeing the Esquimaux or Kamtschadale feasting on putrid fish and rancid oil; but the Esquimaux or Kamtschadale would spit out with disgust the choicest viands of the European epicure. A Laplander can form no conception of the wealth of a man who does not possess a single rein-deer; and pities him who never feasts on the flesh of the bear, nor drinks the oil of the seal or the whale. A Turk imagines that the enjoyment of a man who does not smoke cannot be greater than that of a beast. A man in clothes appears as ridiculous to an Indian of California, as a monkey dressed in human apparel does to the common people of Europe.

Notwithstanding all the differences of climate, almost every individual, from habit and sentiment, is disposed to give a preference to his native land. The Greenlander will not abandon his icy coasts, and the management of his frail *kajak*, for any other country or employment. To the Icelander no other spot on the globe has such charms as Iceland. The Kamtschadale in his *jourt*, surrounded by deserts and tempests, believes his native land to be the most eligible part of the earth, and considers himself the most fortunate and happy of human beings. The Laplander, in the midst of mountains and storms, enjoys good health, often reaches old age, and would not exchange Lapland for the palace of a king. The native of Congo believes that every other part of the world was formed by angels; but that the kingdom of Congo was the workmanship of the Supreme Architect, and must therefore have prerogatives and advantages above the rest of the earth. Although every other tie were broken, the dust of their fathers would bind most men to their native land. Let not the cold skeptic deride the thought. The native of Asia frequenting the tomb of his ancestors, or the afflicted wanderer of the American wilderness piously pulling the grass from the grave of a departed relative, will awaken sympathetic emotions in every ingenuous and affectionate mind.

In the attachment to country we have an auxiliary to our social affections, and a bond for uniting men in large communities. But the attachment is not so strong as entirely to prevent dispersion, or hinder migration to unsettled countries by an oppressed or overflowing population. As men, generally in every climate, are pleased with their country, and love it above every other, so in every stage of society they give the preference to those modes of life to which they have been accustomed. Hence changes and improvements in the economy and intercourse of any people are the result of a slow and gradual progress. Although men may be well pleased with their several circumstances, yet we must never forget that the most exalted enjoyment of the rational being flows from the acquisition of knowledge and the practice of virtue.

It thus appears, that we need not be forward in affecting to commiserate the destiny of those who are placed in circumstances different from our own. Their habits and sentiments are accommodated to their condition, and they would not exchange situations with us. As to climate, we are by no means to imagine that tropical countries are perpetually scorched by an unclouded sun; or that the inhabitants of the polar circle, in winter, are buried in total darkness. Captain Cook informs us, that in general the tropical regions seldom enjoy that clear atmosphere observable where variable winds blow, nor does the sun shine with such brightness. A dull whiteness, that seems a medium between fog and clouds, for the most part, prevails in the sky. This is an advantage; for otherwise, the probability is, that the rays of the sun being uninterrupted would render the heat insupportable. The nights, nevertheless, are often clear and serene.

On the other hand, in high latitudes, although the sun be withdrawn, yet the inhabitants are not enveloped in complete darkness. At Spitzbergen, a sort of twilight, the splendor of the Aurora Borealis, the stars, and the reflection of the snow, serve to light the hunters on their excursions, and enable them to continue the chase during the long night of a hyperborean winter. Hearne tells us, that in the vicinity of the Athapuscow lake, in the middle of December, the brilliancy of the Aurora Borealis and the stars, even without the assistance of the moon, made it frequently so clear all night, that he could see to read a very small print. The Indians make no difference between night and day when hunting the beaver. It may be added, that the annual distribution of heat over the surface of the earth is by no means so unequal as many persons are apt to imagine. The seasons give occasion to different employments, according to the climate and the nature of the country; they also relieve insipid uniformity, and give variety to the appearances of the world, and to the pursuits of man.

Thus, from the physical constitution of the globe, its water and dry land, its mountains and valleys, its different soils and different climates, there is no argument against the perfections of Deity; for on the greater part of the earth man can subsist, and that with equal degrees of happiness. Where man does not or cannot subsist, other sentient beings find a place of residence, and a scene of enjoyment suited to their natures. No part of it is void of animal existence. If there be any argument, drawn from any part of the earth, against the divine attributes, it must equally apply to every part; and, if it be admitted that any part of it exhibits indications of wisdom and goodness, the admission must be extended to the whole. The earth is truly a convenient and pleasant habitation for man and other living creatures, and bears abundant testimony to the wisdom and goodness of the Creator.

It may be pleaded, that mankind at times are afflicted by ungenial seasons, scanty crops, and consequent famine; and that earthquakes, hurricanes, and inundations, overthrow the works, disappoint the hopes, and destroy the enjoyments or the life of man. That, to a certain extent, these things occasionally happen, must be admitted; that they constitute a difficulty, and may be alleged as an objection against the attributes of Deity, need not be denied. But here, as in other instances of the same kind, the difficulty arises entirely from our ignorance; and in proportion as knowledge increases, the difficulty will disappear. I meet the objection with these observations—that the world is governed by general laws; and that this constitution of things is adapted to the nature and condition of man, as an intelligent and active being, in a state of trial and discipline, whose capacities must be unfolded, and his virtues improved by trial and exercise.

All the phenomena prove that the world is governed by general laws. Although these laws be wise and good, yet they may sometimes interfere, and by their interference produce partial evils. For example, the laws of gravitation, of the equilibrium of fluids, and of the disturbance of that equilibrium by heat, are formed and arranged by wisdom and goodness; but in the administration of these laws, such a concurrence of circumstances may sometimes happen as to produce partial evils. High winds arising from the disturbance of the equilibrium of the aerial fluid by heat, may cooperate with the action of the sun and moon, and occasion remarkably high tides. The combinations of the same general laws may produce tempestuous commotions in the atmosphere, causing partial evils. There is reason, however, to believe that even these tempestuous commotions are subservient to general good. The storm that commixes the atmosphere and the ocean is, probably, one grand means of purifying the air contaminated by respiration, vegetation and combustion. The effect of general laws may be partial evil; but it unquestionably is general good. There are no general laws, either in the natural or moral world, that are more injurious than advantageous.

It may be said, Why is not the good produced without the evil? Why are not the general laws so constituted, as to yield all the advantages which we derive from them without any of the disadvantages? Or, if they cannot be so constituted, why are not the disadvantages prevented by special interpositions? That the world should be governed by general laws is not only proper, but indispensably requisite, in order to the regulation of human conduct. If there were no general laws, man would be the sport of irregular occurrences, and wholly at a loss how to act. He would be suddenly defeated in all his undertakings, and reason would be of no avail for the direction of his steps. If the sun rose and set at irregular and uncertain periods; if the return of the seasons were at variable and unknown intervals; if the tides followed no regular course, man would be obliged to act at random, and would be tossed to and fro by circumstances which he could neither foresee nor prevent. But general laws every where obtain; and man can observe them, and act accordingly. They serve as beacons for the direction of his course, and he can use them almost every moment in the voyage of life. Whether general laws could be so framed as to produce all the good effects which we derive from them, without any of the evils, we know not, nor is it needful to institute any inquiry on the subject; for although it were possible that they could be so constituted, yet such a constitution would be improper; and it would be equally improper to prevent the partial evils by special interpositions.

If man were exposed to no danger; if at all times he were secure from want, and disappointment, and pain, he would be a careless, lazy, stupid, and unhappy animal. Place the human being, constituted as he is, in a situation where exertion would be either useless or needless, where the difficulties were insuperable, or where every object of desire spontaneously flowed in upon him, and he would be miserable. If the course of things were invariably accommodated to our wants and desires; if, either by general laws or special interpositions, every evil were infallibly prevented and every good thing secured, then prudence and industry would be altogether useless. There would be no room for human skill, and no motive to human action. There could be no display of skill where every object of desire was certainly obtained without it; and no motive to action where nothing could be gained by foresight and industry, and nothing lost by inattention and sloth.

A state where dangers are to be provided against and averted by foresight, caution, and vigilance; where wants are to be supplied by industry and prudence; enjoyments procured by diligence and ingenuity; difficulties encountered, and trials borne, with courage, fortitude, and patience; where there is still something to excite desire, cherish hope, and stimulate and reward exertion; such a state accords with the constitution of the human being, and is calculated both for his improvement and happiness. Such is the state of this world; fitted to rouse our energies, to animate our activity, and to reward persevering industry. Whenever, to any individual, the world ceases to be such a state, life stagnates, enjoyment flies away, and the consciousness of existence becomes a burden. Now, tempests and floods, and other partial evils resulting from the operation of general laws, are means of exercising and improving our faculties, of giving scope to prudence, fortitude, and activity, and thus promoting our happiness. Besides being suited to our rational and active nature, there is reason to believe that those phenomena which occasion partial evils are productive of great general benefit in the economy of the world. But here our ignorance intervenes, and in a great measure prevents us from tracing the steps of the Creator in his government.

2. The nature of some of the inferior animals.

It is not against the inanimate parts of the world only that the objections of the skeptic have been directed: different departments of animated nature have furnished him with materials of querimonious declamation. "Why are we infested with such multitudes of ferocious and venomous animals, which endanger the safety, and often destroy the life of man? Why does the earth abound with useless and noxious creatures; with myriads of insects, which frequently counteract our labors, destroy the fruit of our industry, torment our persons, and devour the means of our subsistence?" With respect to declamation of this kind, it may be observed, that nothing is more common than to take certain principles for granted, and to reason from those gratuitous assumptions as if they were incontrovertible truths, although not a word has been said in proof of them. If any phenomena do not obviously and exactly agree with those assumed principles and preconceived notions, the persons who have embraced them murmur and complain, as if disorder reigned in the universe, and as if the vestiges of goodness were buried under the rubbish of irregularity and imperfection.

Some persons, resembling the Ouadelim Arabs, who fancy that the sun rises for them only, have ambitiously assumed that not this earth merely, but all the splendid luminaries of the firmament also, were formed solely for the accommodation and comfort of man. On this proud assumption they may wonder why there is such a vast apparatus of planets and fixed stars, which by their feeble light impart such inconsiderable advantages to the earth. But the moment that we think of numerous orders of intelligent beings stationed in the different provinces of the universe, and inhabiting worlds suited to their different organizations and faculties, the misconception and the difficulty pass away. Others, more modest in their pretensions, claim for man this lower world only, with the common advantages of the system. This claim they seem to advance for him exclusively, and to suppose that the world should furnish a scene of enjoyment to him alone, while no other creature should partake of the rich feast provided by the bountiful Creator, but in subserviency to man's pleasure and gratification. This assumption is equally gratuitous and false with the former, although not to the same extent. Man, indeed, is the noblest inhabitant of this world, and has dominion over the inferior animals; but to them as well as to him the Creator has given a charter to inhabit the earth, and there to enjoy a scene of happiness suited to their natures. In some instances, it may be from invading those parts of the globe which the sovereign Distributor of the earth has allotted to them as their domain, that man exposes himself to their vengeance.

The relations and dependencies of the different orders of sentient beings we at present do not fully comprehend. Perhaps a certain concatenation runs through the whole extent of animated nature, the lowest order of sentient creatures being closely connected with inorganic or vegetable matter, and, in the ascending series, every order joined to that which is immediately above it, till the highest is linked to the throne of the Creator; or some gradation and concatenation of this kind may obtain among the innumerable worlds stationed in the immensity of space. Such speculations are above our reach. We do not understand all the relations and dependencies of animated nature even in our own world. If one class of sentient beings, which we think the most useless or noxious, were removed, this would perhaps pave the way for the destruction of a second; the destruction of the second might ensure the extinction of a third; so that we are unable to calculate what might be the consequences of withdrawing any one species of living creatures from the face of the earth.

The Creator may surely, in a consistency with wisdom and goodness, make provision in the same world for different orders of sentient beings. And, if he do so, he may, likewise, in a consistency with the same perfections, place in that world the several orders of beings for whom he has made provision, if the happiness of one order do not interfere with that of another, or if the interference, like general laws, produce general good, and only partial evil. If this principle be admitted, which I think it may, it will go far to vindicate the ways of God with respect to the sentient inhabitants of this globe. If the earth were overrun with rattlesnakes; if lions and tigers lay in ambush in every thicket; this would certainly be too much for the precaution, the vigilance, and the activity of man. It would overpower instead of exercising his faculties; it would destroy his happiness, instead of promoting his improvement. But ferocious and venomous animals are thinly scattered over the globe. Elephants and buffaloes feed in great herds; but lions and tigers, like robbers, are few in number, and lead a solitary life. There are multitudes of the serpent kind, but only a few are venomous. Their fangs are excretory ducts connected with the poison-bag; and the very action of the jaws which inflicts the wound mechanically injects the poison into it. These few are a protection to all the serpent kind. [Pl. XIV. fig. 4, 5.]

The Creator has implanted in every living creature the desire of self-preservation, and has also bestowed upon each of them some means of security and defence in aid of this desire. The defensive weapons of some animals are far more formidable than those of others. The fang of the serpent and the tooth and paw of the lion are instruments of defence or offence, like the horn of the bull or the hoof of the horse: they are more terrible to others, but they are beneficial to the animals themselves. Instruments of defence are as needful to the animal as means of procuring food. Indeed, these often run into each other: in many instances the same organization is employed for both purposes. If any instrument of defence be unobjectionable; if we admit the tooth of the dog and the hoof of the horse to be consistent with wisdom and goodness, then our objections against the paw of the lion and the fang of the viper can be of no great weight. In both we find weapons of defence; there is merely a difference in the degree of force. If, in the one case, the weapon is more formidable, it is a more sure protection to the animal, and a motive to greater caution in awakening its anger. The venomous tribes serve to arouse the vigilance and exercise the ingenuity of man in avoiding their bite, or in expelling or neutralizing their poison. In this way they contribute to the development of our powers, by presenting difficulties and dangers which are not overwhelming, but which serve to awaken activity and quicken ingenuity.

Man must be careful, vigilant, and active in cultivating the earth, in clearing it of weeds, and in superintending the growth of his crops. He must exercise a similar care, vigilance, and activity, in avoiding the tooth of the serpent and the paw of the lion. These and similar animals are, for the most part, natives of climates where nature dispenses her treasures with rich profusion; and therefore, if the faculties of man be not expanded in soliciting the earth for subsistence, they find a certain degree of exercise in watching and providing against surrounding dangers. Besides, venomous and ferocious animals, which are comparatively few in number, teach us duly to value the inoffensive kinds. It is by contrast chiefly that we learn the worth of our enjoyments. If the stream of felicity flowed without mixture and without interruption, it would cloy the appetite. Some bitter ingredient must be cast into our cup to make us relish what is sweet. We are more sensible of the beauties of a fine day after experiencing a tempest. The barren wilderness illustrates the value of the fertile field; and, in like manner, the ferocity of the tiger may teach us duly to estimate the meekness of the lamb; and the envenomed tooth of the *cobra capella*, to value the innocuous qualities of the frog.

It has been remarked, that throughout nature things which have a relation to each other for the advantage of man are found together. Thus, mines of gold and silver abound in South America; and mercury, which is used in separating these metals from their ores, is also found there. Coal, which is so useful in smelting iron ore, is found along with it. Compensations, in like manner, accompany what is noxious. Travellers often fall ill of nervous fevers on the road between Caraccas and Cumana; but the valley and forests that emit the dangerous exhalations which occasion these fevers, also produce a tree, the bark of which furnishes a salutary remedy for the disease. Where there are many venomous reptiles, there the herbs which are the most certain antidote to their poison are found in the greatest plenty. If dangerous serpents abound in intratropical America, there the *habilla de Carthagena* grows, by eating a little of which, fasting, the hunters in their excursions in the woods fortify themselves against the bite of the rattlesnake itself.*

* Ulloa, Voyage Historique, &c., liv. i. c. 6, & liv. vi. c. 10.—The habilla de Carthagena is a sort of bean which grows on a kind of willow. It is about an inch broad, nine lines long, flat, and heart-shaped. It is of an extremely hot nature, and an ordinary dose is less than the fourth part of a bean or kernel. For an account of the rattlesnake herb, by which the natives of Louisiana heal the bite of that snake, see Le Page de Pratz, History of Louisiana, vol. ii. pp. 43—73, English translation.—*Carver's Travels*, p. 482.

Horses, cows, dogs, and fowls, seem to have an innate sense of their danger from snakes, and show evident symptoms of fear in approaching them, even when dead; but hogs, so far from being afraid of them, pursue and devour them with the greatest avidity, totally regardless of their bites.—*Carver's Travels*, p. 483. *Weld's Travels*, vol. i. pp. 202–3. Hesychius of Miletus informs us that Neptune employed storks to exterminate serpents from the island of Tine, in the Grecian Archipelago.—*Tournefort, Voyage*, tom. i. p. 258. *Virg. Æn.* xi. 751. *Juvenal*, xiv. 74. *Hor. Car.* lib. iv. *Od.* iv. l. 11. *Iliad*, xii. 201.

Captain Seely, in his "Wonders of Ellora," p. 452, second edition, speaks

To some persons, those animals which in general estimation have a most disgusting appearance furnish an agreeable article of food. Depons* informs us that, on the banks of the Lake Tacarigua, in South America, the Indians and some of the Spaniards make their most delicious meal on the *iguana*, a kind of lizard of a greenish color, and about two feet and a half long. This to persons unaccustomed to it would form a most loathsome dish. Dr. Shaw† was told, that in Cairo and in its vicinity upwards of forty thousand persons lived on lizards and serpents only. The savage devours with avidity the vermin that prey upon him. In some countries, frogs are esteemed a delicate dish. Locusts at times sweep the face of a country like a conflagration. No green thing escapes their devouring tooth, and ruin marks their progress. But, besides furnishing a rich feast to the locust-bird, starlings, sparrows, and swallows, their myriads yield a nutritious repast to the Arab; and thus in some measure compensate the desolation which they have occasioned.

The bee may sting; but it furnishes us with honey and wax. Some insects toil diligently in our service; and others, which at first sight seem useless or loathsome, may be applied to beneficial purposes. The silk-worm provides for us the materials of a fine attire. The cochineal imparts a beautiful color to our raiment. Leeches, cantharides, and other inferior animals, can be made to contribute to the preservation of our health, or the removal of our diseases. Many small animals may, no doubt, be applied to valuable purposes with which we are yet unacquainted. Here, as in other departments of nature, there is room for patient observation and careful experiment; for the exercise of ingenuity and the progress of discovery. We may never, perhaps, find out all the uses of every species of insects; but even at present we know enough to justify the ways of God to man.

Thus, when we survey the inferior animals, we perceive that their vast number and variety exhibit a brilliant display

of the *mongos*, a little animal of the ferret kind, which eagerly fights large snakes, provided a particular grass grow near. If bitten, it eats a quantity of this grass, vomits, rolls itself on the ground, and again engages in the combat; but it will by no means act offensively if this particular grass be not at hand. For *mongos*, see also *Edinburgh Cabinet Library*, vol. viii. p. 36.

* An agent of the French government at Caraccas, and author of a "Voyage to the Eastern Part of Terra Firma, or the Spanish Main, in S. A., in 1801—1804" (translated, 1806, New York).

† A celebrated traveller, educated at Oxford, and for several years chaplain to the English factory of Algiers. While there, he made various excursions to examine the curiosities and antiquities of the country. His Travels contain an interesting and accurate account of Barbary and the Levant, and particularly of Egypt. He died at Oxford, 1751, æt. 59.

of the perfections of Deity. Wisdom and goodness are manifested in the bodily organization and instinctive propensities of every species, as well as in the provision made for supplying their wants. When viewed in reference to man, they harmonize with other parts of the scene in which he is placed, serving to awaken his vigilance and activity, to exercise his ingenuity, to aid him in his labors, to supply his wants, and to diversify his enjoyments.

Why, it may be inquired, do living creatures prey upon one another? Why do not all animated beings on earth live together in harmony, and with mutual affection partake of the common bounty of the Creator? That animals prey on each other cannot be denied. Their doing so is agreeable to the constitution of nature; for the bodily conformation of some of them furnishes unequivocal evidence that they were designed to wage war against others; and fact corresponds with the indication. A scene of hostility pervades the ocean, and prevails to a considerable extent on dry land. Among the inhabitants of the waters, the strongest, with a few exceptions, prey voraciously upon the weaker. Flight and pursuit, escaping from one and devouring another, constitute their employment. On land, the lion and tiger encounter each other; both of these prey upon other quadrupeds, and attack even man himself. Man also is a carnivorous animal.

The hostility that prevails among sentient beings exhibits a strange scene, and seems, at first sight, to militate against the attribute of goodness, in the Author of the system. But when we reflect that this scene in a great measure stands alone, and is every where surrounded by plain indications of benignity, we must feel ourselves constrained to pause before we come to any conclusion unfavorable to the perfections of Deity. Although we could give no explanation whatever of this phenomenon, yet in the midst of so many proofs of goodness, it would rather become us humbly to acknowledge our ignorance, than to impeach the attributes of the Author of all our mercies. Puzzling as the fact under consideration may appear, we need not abandon it in despair, as incapable of explanation. The following observations may satisfy us that it is not incompatible with that wisdom and goodness which are so obvious in the general constitution of the world.

First, Immortality upon this earth, as Dr. Paley has justly observed, is out of the question. On the supposition of immortality here, it is obvious that the process of propagation must soon terminate. The world would soon be replete with inhabitants; there would be no room for more, and a great source of animal happiness would be dried up. The term of life assigned to different animals can form no objection; for if we object to the short term of a day, we may object, on the same principle, to a hundred years, or to any other limited period; and still ask, Why was not the term of life longer? The consonancy of death with wisdom and goodness must be admitted; and the term of life assigned to any animal cannot fairly be urged as an objection. The whole question then is reduced to this point—the manner in which the sentence of death is carried into execution. This can be only by the decays of nature, by disease, or by violence. When the animal dies by violence, I apprehend that, generally speaking, it suffers much less pain, than when it dies by the decays of nature, or by the operation of disease. The pain may be more intense, but it is of much shorter duration.

> Harsh seems the ordinance, that life by life
> Should be sustained; and yet, when all must die,
> And be like water spilt upon the ground,
> Which none can gather up,—the speediest fate,
> Though violent and terrible, is best.*

Man, under the decays of nature or the pressure of disease, has commonly some tender friend to sympathize with him, and to assist him. When he is destitute of this sympathy and assistance, we deem his condition the most deplorable to which a human being can be exposed. Who, without feeling his heart melt within him, can think of the aged or sick Indian in the wilds of Canada, unable any longer to travel with his band, covered over in the depth of winter with a few bushes, and left alone to perish with cold, and hunger, and disease? But the beast, not under the immediate protection of man, that dies by disease or old age, is in a state resembling that of the Indian. A violent death abridges instead of increasing suffering.

Secondly, The present constitution of things does not diminish the happiness of the inferior animals during life; they are afflicted by no painful anticipations. Attack and defence, flight and pursuit, exercise their activity, and seem to constitute no small part of their enjoyments. The ocean is a great scene of hostility; and so far as we are able to judge of its inhabitants, their pleasure is not small. It seems in no degree lessened by the perpetual war that is going on. On the dry land, the dangers to which animals are liable do not deprive them of the happiness of which their natures are suscepti-

* Montgomery.

ble. It is only in the moment of actual suffering from violence that the present constitution of things gives the animal any pain.

Thirdly, While the present constitution of things does not appear to subtract from the happiness of sentient beings during life, and while it abridges the pains of death, it is the means of providing subsistence for a greater number and variety of animals than could have otherwise existed in the world, and thus increases the general sum of happiness. If all animals had been herbivorous only, it is obvious that the same number and variety of them could not have subsisted in the same place, as may do so according to the present constitution. But, within certain limits, which have never yet been exceeded, the more numerous animals are, the greater is the sum total of happiness on earth. I have already had occasion to observe, that the fecundity of the several tribes of animals is well suited to their several terms of life, and to the dangers and waste to which they are exposed. Not one species perishes by the voracity of others. The predaceous kinds are not nearly so numerous as those of a more mild and inoffensive nature; there are thousands of sheep for one tiger; innumerable larks for one eagle.

The fecundity of animals enables us to regulate the numbers of any kind, according to our wants or our pleasure. It is also the means of filling up the blank where man does not dwell. Such is the constitution of nature, that if we turn up the soil in any spot, it will ere long be clothed with verdure, although we sow nothing there. Seeds will find their way to the place. In like manner, although man retire from any part of the earth, it will not remain an untenanted wilderness. Some of the inferior tribes will take possession of it. It will still be a scene of life and of enjoyment. If man return, he can make the inferior animals of every kind retire before him, contribute to his subsistence, or aid him in his labors.

The depredations of animals, then, upon each other, is only an apparent, not a real evil: it forms no solid objection against the goodness of Deity, for it does not appear to diminish the happiness of any animal during life. It abridges suffering at death, and furnishes subsistence to a greater number of animals than could otherwise live on the earth. Moreover, the inferior animals have no moral nature to be depraved by the system of depredation, or to be improved by the sufferings preceding death in the slow decays of nature, or in the progress of disease. Man may act towards them in such a way as to deprave his moral faculties: wanton cruelty will harden his heart. But if he make only a legitimate use of his dominion, he may avail himself of them, either to assist him in his labors, or to supply his wants, without any perversion or debasement of his nature.

3. The pains and sorrows to which man is exposed from his constitution, and the circumstances in which he is placed.

We may here take notice of an objection on which some persons seem to lay considerable stress. They complain that the progress of population always presses upon or outstrips the means of subsistence, and that the consequent unavoidable misery is an evidence that the Author of Nature is careless about human happiness. This constitution, however, is in exact accordance with the other parts of the system, and produces most beneficial effects: it calls forth exertion, sharpens ingenuity, prompts to the appropriation and culture of the soil, and to the arts and improvements which enrich and adorn society; it spreads mankind over the different parts of the globe, and conducts the genial stream of knowledge and civilization to every country. The band of wandering savages subsists by gathering the spontaneous productions of the earth, and by hunting and fishing. When their numbers multiply, they seek an addition to their precarious maintenance by a partial cultivation of the ground. The principle of multiplication, acting as a propelling power, presses them forward in the career of agricultural improvement. Arts are invented, commerce is undertaken, the variety of roots, fruits, and grains, is accommodated to a growing community.

When, by a skilful agriculture, and a judicious adjustment of crops, the soil is made to produce the greatest possible quantity of human food, then cultivation has attained perfection. In no country, however, has agriculture hitherto reached this point; for in many parts even of China, of the great population of which so much has been said, the cultivation of the earth is in a very imperfect state. Unoccupied or thinly inhabited regions are open to receive an overflowing or discontented and restless population, just as some part of our native country commonly receives us when we quit the paternal roof which sheltered our infant and youthful years. These emigrants carry along with them part of the manners and attainments of their native land, and diffuse knowledge and civilization more widely over the earth. In this way industry is kept in constant activity, and mankind are gradually improved. But while the principle of population is of such vast and beneficial importance in the course of human affairs, it is not to be forgotten that the passions and appetites ought to be under the guidance of reason ; and that marriage ought not to be entered into without foresight and a due consideration of circumstances. In densely-peopled countries, prudential restraints operate as a silent, but powerful check on the increase of the species. Instead, however, of dwelling on this subject, we shall pass on to other topics.

From the constitution of our nature, and the circumstances in which we are placed, we are unavoidably exposed to occasional pain, grief, and disease; and we must at last die. Pain, grief, and disease are sometimes entirely owing to the abuse of free agency; and sometimes they are greatly increased by it. In so far as they flow from this source, we have ourselves to blame; and this part of the subject has been considered in a preceding section. At present, it is only that portion of pain and grief to which we are unavoidably exposed by the constitution of our nature and the circumstances in which we are placed that claims our attention. This, comparatively speaking, forms but a small portion of human suffering. If from the sum total we subtract the product of imprudence, folly, and vice, we will leave but a small remainder behind; and with respect to this remainder, it is the result of wise general laws, and is productive of good effects.

Our body is a material fabric, and must be subject to those general laws by which matter is governed. General laws, as we have already seen, are highly advantageous. Without them we would be altogether at a loss how to act. They are beacons for the regulation of our conduct. Yet from their operation partial evils may arise. The law of gravitation is good ; but a stone may fall, and hurt or kill a man ; or a man may fall and be hurt or killed. But why were we made susceptible of pain ? To this it may be replied, that we cannot easily conceive a material being susceptible of pleasure, and not also susceptible of pain. Certain it is that pain is often the means of giving a higher relish to pleasure, while its removal is a source of sweet enjoyment. It is even productive of good effects in the measure in which we are exposed to it; for who would wish to be deprived of that sensibility which is the occasion of pain ? We may even go farther, and assert that it proves benevolent intention ; for it is never inflicted on us merely for its own sake, but is a sentinel to watch over our preservation and our happiness.

What has been said of pain may be applied in some measure to grief. Some sorrows are counterbalanced by concomitant pleasures. "The joy of grief," at first sight, may seem a solecism in language; but the propriety and beauty of the expression are recognized by those who have attended to the operations of their own minds. I pass over the griefs which arise from false estimates, lofty pretensions, violent passions, and the whims of a sickly and perverted imagination. They are the creatures of our own folly, and can never with justice be set down in the account against our Creator. The mortifications, the griefs, and the sufferings from political institutions of society, fall under free agency. If men chose, those things might be otherwise. If the institutions are really best for all, there is no reason to complain of them. If they be the means of sacrificing the happiness of the many to the interests or caprice of the few, this is an abuse of free agency, and falls under the observations made in a former section.

Similar remarks may be applied to bodily disease. Where there is no neglect or perversion of our means, no abuse of free agency, disease does not often occur. It is a common and a true observation, that exercise and temperance are the best physicians. Most persons find occasion for the first of these in the course of their lawful avocations: it is our own fault if we neglect the last. By industry we are able, generally speaking, to procure the means of satisfying the desires of nature: to pamper luxury is injurious to health; for if one die of hunger, or of disease induced by too spare a diet, ten hasten their dissolution by repletion and surfeiting. When we consider the complicated mechanism of the human body, and the variety of circumstances in which we may be placed without injury, we are justified in saying that health is not easily impaired. It often remains uninjured, or is but little affected, although the body be in very different states and circumstances.

The decays of old age, or long-continued disease, reconcile us to dissolution. The love of life, in general, is sufficiently strong to induce us to use every means in our power for its preservation, and to submit to all our trials rather than resign it. Still the mind, as well as the body, is gradually prepared for a change. Death has a formidable aspect to a person in health; but to one who has passed through the gradually-declining stages of old age, or of lingering sickness, it has lost much of its terror. Every step prepares for that which is to follow. Death is the lot of humanity, and the time when we shall undergo that change is uncertain. This uncertainty is a wise appointment. It preserves the spur to caution and activity, neither checking the spirit of enterprise by the prospect of impending dissolution, nor yet encouraging temerity, presumption, or procrastination, by the certainty of a prolongation of life.

This world is not a place for our everlasting residence. Here we cannot reach the perfections of our nature; and if we could, this earth would be found an unsuitable habitation. It would present too many causes of irritation, and would not afford adequate sources of enjoyment. It is fitted merely for the introductory stage of our progressive being. It is admirably adapted to our intellectual and moral improvement in that stage; and we are called off before the scene becomes unmeet for us. The generations of the human race pass away in succession to another state of existence, and this succession seems accommodated to the greatest sum total of happiness on earth. The young have the keenest relish for the world and its enjoyments. True, indeed, the evening of a good man's days is by no means comfortless; but his chief happiness arises from the retrospect of a well-spent life, and the anticipation of a nobler state of being. In this world, we pass through a course of education for a better.

Is it objected that many of the human race make little or no improvement, either intellectual or moral? If they neglect their talents and opportunities, the blame is their own; and their misconduct can form no objection against the Author of their existence and Fountain of their mercies. Do you complain that you are cut off in the midst of your days? Your constitution is not indestructible, and in certain circumstances, you expose yourself to disease, which, operating according to general laws, may terminate fatally. In this, however, there is no *chance*, for *chance* is introduced only when knowledge ends; it is merely the operation of general laws to which we may not have duly attended. Many children die. But that so many infants die, is owing, in no small degree, to carelessness and mismanagement. In some foundling hospitals, scarcely any survive. In healthy situations, with healthy and attentive parents, few die. If children were not liable to death, parents would be utterly careless; but by the existing constitution of things, the carelessness of parents is punished by the wounds which the death of children inflicts on parental affection. As to the future state of children, we need have no difficulty in confiding it to that great and gracious Being who gives such innumerable instances of goodness in every department of nature around us.

Men are placed in very different circumstances in the world, and exposed to a variety of vicissitudes. But difference of external circumstances seems to occasion no diminution of happiness. The laborer who earns his daily bread by the sweat of his brow, is as healthy and as happy as he who wears a crown. The one is insensible to what we consider the hardships of his condition, the other is familiar with what we think his enjoyments; and in point of happiness, habit and sentiment have set them nearly on a level. That constitution of things by which trials overtake us, is adapted to the state of discipline in which we are placed, and aids conscience in indicating the path of duty, by checking our aberrations, curbing our passions, and producing salutary effects both on our intellectual and moral nature.

Without trial and suffering, both in ourselves and others, some of our best affections would lie dormant, and some of the noblest energies of our nature have no room for action. Where can courage, and fortitude, and patience, be acquired and displayed, but in the face of difficulties, and under the pressure of affliction? The skilful and intrepid mariner does not acquire his knowledge, dexterity, and courage, on the bosom of the sleeping lake. He must encounter the hardships and perils of the tempest. The hardy and fearless warrior is not trained in the calm, sequestered vale of pastoral life: he must mingle in the fatigue, noise, and carnage of martial achievements. In like manner, the candidate for moral and intellectual excellence must not slumber away life on a bed of down: he must submit to laborious exertion and severe trial. How is a compassionate sympathy excited, except by scenes of sorrow and suffering? Hence the Hebrew sage, who was no inattentive observer of the moral tendencies of our nature, says, "It is better to go to the house of mourning than go to the house of feasting; for by the sadness of the countenance the heart is made better." Our sufferings and sorrows, even when they produce no salutary effect on ourselves, may prove beneficial to others. Prosperity and adversity are different modes of education and trial, and our limited knowledge does not enable us to say which of them, in any given case, requires the steadiest exercise of virtue, or is the most efficacious means of improvement. In a higher stage of existence, there may be no need for courage, fortitude, patience, and pity; because there danger and suffering may be unknown. But there may be need for the temper formed by those virtues.

We have seen that the terraqueous globe is admirably fitted up as a place of residence for sentient beings; and a gradation of sentient beings is consistent with the wisdom and goodness of Deity. To deny this were, in effect, to deny that any creature could exist in a consistency with the divine perfections. If we declare it to be incompatible with wisdom and goodness to form creatures in any one point of the scale, we may, with equal propriety, make a similar declaration with respect to any other point. The earth is replenished with a great variety of animals, and it is fitted for being a scene of enjoyment to every species. Many of the kinds prey upon others; but this constitution impairs the happiness of none: it is the means of supporting a greater number than could otherwise have found subsistence, and consequently increases the sum of enjoyment. Man is the noblest inhabitant of the earth, and has dominion over the inferior creatures. He is a rational being, a free agent, the subject of moral government. He may abuse his liberty, and subject himself to a corresponding punishment. But this punishment results from his own perversity, and cannot be pleaded as an objection against the wisdom and goodness of God; for the agent might have acted otherwise, and not only avoided the punishment, but enjoyed reward. Moral evil, therefore, and all its consequences, must at once be laid out of the question, when estimating the perfections of Deity by his works and government.

The inferior animals are guided by instinct, and their nature is stationary. Man, however, is not only a rational but a progressive being; and he is endued with a restless activity. Here he is placed in a school, not seated at a banquet; and both his improvement and happiness are promoted by exertion. Every thing around us is fitted to our constitution, to stimulate activity, to encourage hope, to reward industry. Nature does not spontaneously supply our wants and gratify our desires; but she yields to our ingenuity and diligence. A succession of wants and desires prompts to a repetition of exertions, and promotes progressive improvement. Difficulties occur; but they are not insuperable: they awaken our energies and exercise our talents. The prize is within our reach; but we must run vigorously in order to obtain it. The victory may be acquired; but we must combat valiantly in order to remain masters of the field. Of this constitution of things men may complain; they may complain that we must run to obtain the prize, that the crown is not set upon our head till we are qualified to wear it. This, however, is the only constitution of things suited to our nature. If we were placed in a scene where every want was easily and instantaneously supplied, and every wish at once gratified without contrivance or exertion; where there was no room for hope or fear, for ingenuity or activity, for the operation of the affections of the heart or the powers of the understanding, we would be torpid creatures, overwhelmed with melancholy languor, and scarcely able to support the burden of life. But the vicissitudes and trials to which we are exposed call forth our energies, awaken the noblest sensibilities of our nature, and strengthen our best affections.

Disease is not unfrequently the means of leading to the path of virtue: it has a salutary operation on our moral constitution, and prepares us for the rewards of obedience. Death is a departure from the present scene; and we have good reason to conclude that, with respect to those who have acted virtuously here, it is a transition to a more exalted state of being. No virtuous person, then, has reason to complain: the vicious ought to direct their murmurs and complaints, not against the Author of their existence and their enjoyments, but against their own folly and perversity in disobeying the dictates of reason and conscience, and so forfeiting that happiness which the bountiful Creator has placed within their reach.

VOCABULARY.

A.

Anther, a small body which contains the pollen, or fertilizing dust of flowers. The anthers are fixed, generally, on the ends of slender filaments, and surround the germ, or seed-vessel.
Aorta, the main artery of the body, which receives the blood directly from the heart, and distributes it throughout the system.
Articulations, joints formed by the union of bones.
Atlas, the upper vertebra of the neck, and which supports the globe of the head. The name is given in allusion to the fable of Atlas supporting the heavens.
Auricle, a cavity of the heart. Its external shape gives it the appearance of an appendage to this organ; its name is derived from its resemblance to an ear—in Latin, *auricula*.
Azote, which signifies "destructive of life," the same as *Nitrogen*, which see.

C.

Calcareous, composed of lime.
Caloric, the ultimate principle of heat.
Calyx, the flower-cup; the external part of the flower, usually resembling the leaves in color, and containing the other parts of the flower within it.
Capillary, hair-like. The extreme vessels of the body are so called, from their extreme minuteness.
Capsule, the seed-vessel of plants.
Carnivorous, feeding or living on flesh.
Carotid, the name of the arteries which pass up the neck on each side of the windpipe, and convey the blood to the head.
Cartilaginous, gristly.
Cellular, consisting of cells.
Centripetal, tending towards the centre. All bodies on the surface have a tendency to fall towards the centre of the earth.
Cetaceous, of the whale kind.
Condyles, prominences at the ends of some of the bones, intended to afford surfaces for the formation of joints.
Cornea, the transparent covering of the front part of the eye, through which we see the pupil and the iris.
Corolla, the petals of the flower considered as a whole.
Chromatic, having the colors of the rainbow.

D.

Diaphragm, a thin, broad, muscular membrane, extending across the body, and forming the lower extremity of the thorax.

Dioptrics, a branch of optics treating of the refraction of light on its passing through transparent substances.
Dorsal, relating to the back.
Duodenum, the first of the small intestines, next to the stomach, and receiving the food from it.

E.

Elytra, the external, hard, scaly wings of many insects, as beetles.
Epiglottis, the valve which covers the passage from the mouth into the windpipe.
Exuviæ, the cast-off skin, shells, or other coverings of animals.
Evisceration, removal of the internal organs.

F.

Farina, the same as *pollen*.
Filament, a substance long and slender, like a thread.

G.

Gas, a term in chemistry, nearly the same as *air*. All fluids which are aëriform in ordinary temperatures, are called *gases*.
Gastric, belonging to the stomach.
Glands, so called, from their supposed resemblance to an acorn (*glans*). Their office is to secrete from the blood fluids of various kinds.

H.

Herbivorous, feeding on herbs or grasses.
Hydrogen, one of the elements of water. It can be obtained only in the form of a gas.

I.

Incubation, the sitting upon and hatching of eggs.
Inertia, the property of matter which makes it remain in the state in which it is, whether of motion or rest.
Iris (plural *irides*), the colored ring surrounding the pupil of the eye.

L.

Lachrymal, relating to tears.
Laminæ, thin plates, or layers.
Larva, an insect in its first state, usually called a worm, or caterpillar.
Larynx, the upper part of the windpipe, including the organs of speech.
Lens, any transparent substance of a convex or concave form.

M.

Medullary, consisting of marrow. It is applied also to the substance of the brain and nerves.
Membranes, thin expansions of animal substances, covering all the important animal organs. The stomach is formed of several membranes laid together.
Monopetalous, a corolla consisting of a single petal.
Muscles, bundles of fibrous flesh. In the mammalia, birds, and some reptiles, they are red; in other animals mostly white. They consti-

tute the chief portion of the flesh of animals, and are the parts principally used as food.

N.

Nasal, pertaining to the nose.
Nictitating, winking; applied generally to the third eyelid of birds, and some other animals.
Nitrogen, one of the gases which compose atmospheric air. Its qualities are negative, and its principal use seems to be merely to dilute the oxygen.
Nymphæ, insects in their second or chrysalis state.

O.

Œsophagus, the tube which conveys the food from the mouth to the stomach.
Oviparous, producing young by means of eggs.
Oxygen, vital air; also one of the component parts of water.

P.

Papillæ, small projections on the surface of organs, as on the tongue.
Pectoral, relating to the breast.
Pericardium, the membrane containing the heart.
Peristaltic, worm-like motion.
Petals, the flower leaves, or leaves of the corolla.
Pharynx, the cavity at the back part of the mouth.
Pistil, the part of a flower intended to receive the pollen of the sta mens.
Plumula, a little plant. It is applied to the plant when it first issues from the ground.
Pollen, the fertilizing dust of flowers, produced by the stamens. The same as *farina*.
Prehensile, adapted to seize or grasp.
Process, any elevation of parts of bones.

R.

Radicle, the incipient root of plants.
Retina, a very delicate and sensitive membrane at the back part of the eye, for the reception of the images of objects. It is supposed to be an expansion of the optic nerve.
Ruminating, such as chew the cud.

S.

Saliva, the liquid which moistens the mouth.
Sapid, having taste.
Sensorium, the seat of all sensation, the region of the brain.
Simiæ, the monkey tribe.
Spine, the back-bone; so called from its numerous sharp processes.
Sternum, the breast-bone.
Stigmas, the extremities of the pistils of plants.
Subclavian, lying under the clavicle or collar-bone.
Synovia, a liquid which lubricates the joints, in order to prevent too great friction.

T.

Temporal, belonging to the temples.
Thorax, the chest, formed by the spine, the sternum, the ribs, and the diaphragm.
Trachea, the windpipe.

V.

Valvulæ conniventes, folds formed by the internal membrane of the intestines, and constituting partial valves.
Vascular, consisting of small vessels.
Vena cava, one of the large veins which brings the blood from the extremities of the body to the heart.
Ventricle, any small internal cavity of the body, as the ventricles of the heart, brain, &c.
Vertebræ, separate bones constituting the spine.
Viscus (plural *viscera*), the internal organs of the body, as lungs, heart, liver, stomach, &c.

PAXTON'S

ILLUSTRATIONS;

WITH

DESCRIPTIONS.

INDEX TO THE PLATES.

PLATE I.

THE EYE.

Fig. 1. The *crystalline lens of a fish:* it is proportionally larger than in other animals, and perfectly spherical.

Fig. 2. A section of the human eye. It is formed of various *coats*, or membranes, containing pellucid humors of different degrees of density, and calculated for collecting the rays of light into a focus upon the nerve situated at the bottom of the eye-ball.

The external membrane, called the *sclerotica*, is strong and firm, and is the support of the spherical figure of the eye: it is deficient in the centre, but that part is supplied by the *cornea*, which is transparent, and projects like the segment of a small globe from one of larger size. The interior of the sclerotica is lined by the *choroid*, which is covered by a dark mucous secretion, termed *pigmentum nigrum*, intended to absorb the superfluous rays of light. The *choroid* is represented in the plate by the black line. The third and inner membrane, which is marked by the white line, is the *retina*, the expanded optic nerve.

Within these coats of the eye are the *humors*—*a*, the *aqueous* humor, a thin fluid like water; *b*, the *crystalline lens*, of a dense consistence; *c*, the *vitreous* humor, a very delicate, gelatinous substance, named from its resemblance to melted glass. Thus the crystalline is more dense than the vitreous, and the vitreous more dense than the aqueous humor: they are all perfectly transparent, and together make a compound lens, which refracts the rays of light issuing from an object, *d*, and delineates its figure, *e*, in the focus upon the retina, inverted.

Fig. 3. The *lens of the telescope*.

Fig. 4. The crystalline *lens*, or, as it has been called, the crystalline *humor* of the eye.

Fig. 5, 6. A plan of the circular and radiated fibres which the *iris* is supposed to possess; the former contracts, the latter dilates the pupil, or aperture formed by the inner margin of the iris.

Fig. 7. *a*, *a*, *a*, *a*, the four *straight* muscles, arising from the bottom of the orbit, where they surround, *c*, the optic nerve; and are inserted, by broad, thin tendons, at the fore part of the globe of the eye, into the tunica sclerotica.


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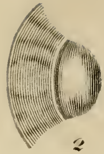

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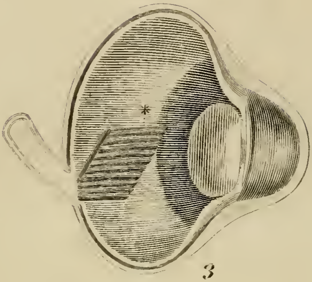

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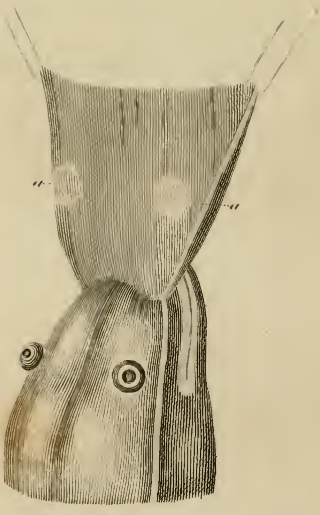

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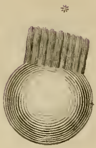

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PLATE II.

THE EYE OF BIRDS AND OF THE EEL.

Fig. 1, 2. The *flexible rim*, or *hoop*, of the eye of birds, consisting of bony plates, which occupy the front of the sclerotica ; lying close together and overlapping each other. These bony plates, in general, form a slightly convex ring, Fig. 1 ; but in the *accipitres* they form a concave ring, as in Fig. 2, the bony rim of a hawk.

Fig. 3, 4, 6. Exhibit the *marsupium:* it arises from the back of the eye, proceeding apparently through a slit in the retina : it passes obliquely into the vitreous humor, and terminates in that part, as in the eagle. Fig. 3, a section of the eye of the *Falco chrysaëtos.* In some species it reaches the lens, and is attached to it as in Fig. 4, 6. In the plate the marsupium is marked with a *.

Fig. 5. The head of an *eel ;* the skin is represented turned back ; and as the *transparent, horny covering* of the eye, *a*, *a*, is a cuticular covering, it is separated with it. Other fish have a similar, insensible, dense, and thick adnata, which is designed to protect the eye ; and it seems especially necessary, as fish have no eyelids.

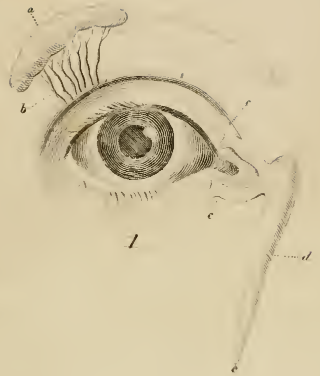
PLATE III.

THE LACHRYMAL APPARATUS, AND NICTITATING MEMBRANE.

Fig. 1, *a*, is the *lachrymal gland:* it is situated at the outer and upper part of the orbit of the eye. This is the gland which secretes or separates the tears from the blood. There are five or six ducts or tubes, *b*, which convey this fluid to the globe of the eye, for the purpose of keeping it moist, and for facilitating its movements; the motion of the eyelid diffuses the tears, and, *c*, *c*, the *puncta lachrymalia* take up the superfluous moisture, which passes through, *d*, the *lachrymal sac and duct*, into the nostril at *e*.

Fig. 2. The *nictitating membrane*, or third eyelid: it is a thin semi-transparent fold of the conjunctiva, which, in a state of rest, lies in the inner corner of the eye, with its loose edge nearly vertical, but can be drawn out so as to cover the whole front of the globe. In this figure it is represented in the act of being drawn over the eye. By means of this membrane, according to Cuvier, the eagle is enabled to look at the sun.

Fig. 3. The two muscles of the nictitating membrane are very singular in their form and action; they are attached to the back of the sclerotica; one of them, *a*, which from its shape is called *quadratus*, has its origin from the upper and back part of the sclerotica; its fibres descend towards the optic nerve, and terminate in a curved margin with a cylindrical canal in it. The other muscle, *b*, which is called *pyramidalis*, arises from the lower and back part of the sclerotica. It has a long tendinous chord, *c*, which passes through the canal of the quadratus, *a*, as a pulley, and having arrived at the lower and exterior part of the eye-ball, is inserted into the loose edge of the nictitating membrane. This description refers also to Fig. 4, a profile of the eye, and Fig. 5, the membrane and its muscles detached from the eye.



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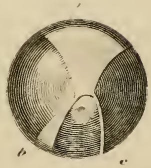

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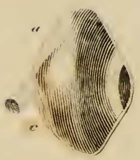

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PLATE IV.

THE HUMAN EAR, AND TYMPANUM OF THE ELEPHANT.

FIG. 1. The organ of hearing: *a*, the *external ear*; *b*, the *meatus auditorius externus*, or outward passage of the ear, leading to, *c*, the *membrana tympani*, or drum; *d*, the *ossicula auditus*, or little bones of the ear; *e*, the *semicircular canals*; *f*, the *cochlea*; *g*, a section of the *eustachian tube*, which extends from the cavity of the tympanum, to the back of the mouth or fauces.

FIG. 2. The bones of the ear magnified: *a*, the *malleus*, or mallet, connected by a process to the tympanum; the round head is lodged in the body of, *b*, the *incus*, or anvil, and the incus is united to, *c*, the *os orbiculare*, or round bone, and this to, *d*, the *stapes*, or the stirrup. These bones are named from their shape, and the names assist in conveying an idea of their form. They are united by ligaments, and form an uninterrupted chain to transmit the vibrations of the atmosphere.

FIG. 3. The *labyrinth*, so named from the intricacy of its cavities: it is situated in the petrous part of the temporal bone, and consists of the *vestibule*, or *central cavity*, three *semicircular canals*, and *cochlea*, so named from its resemblance to the windings of a snail shell, and is best explained by the plate, Fig. 1, and 3.

The vibrations of sounds, striking against the membrana tympani, are propagated, by the intervention of these four little bones, to the *water* contained within the cavities of the labyrinth; and by means of this water the impression is conveyed to the extremities of the *auditory nerve*, and finally to the brain.

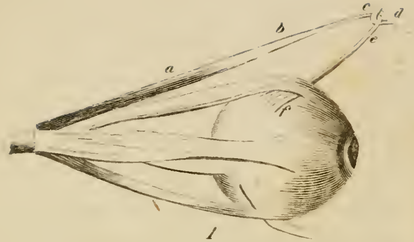
Fish require no tympanum nor external opening to the ear; the fluid in which they live is the medium for conducting sounds through the bones of the head.

FIG. 4. The tympanum of the *elephant*, of its natural size, showing its radiated fibres, supposed to be muscular.

PLATE V.

TROCHLEAR MUSCLE OF THE EYE.

Fig. 1. The *trochlear*, or *superior oblique* muscle, arises with the straight muscles from the bottom of the orbit. Its muscular portion, *a*, is extended over the upper part of the eye-ball, and gradually assumes the form of a smooth, round tendon, *b*, which passes through the pulley, *c*, and is fixed to the inner edge of the orbit, *d*, then returning backwards and downwards, *e*, is inserted into, *f*, the sclerotic membrane. The use of this muscle is to bring the eye forwards, and to turn the pupil downwards and upwards.



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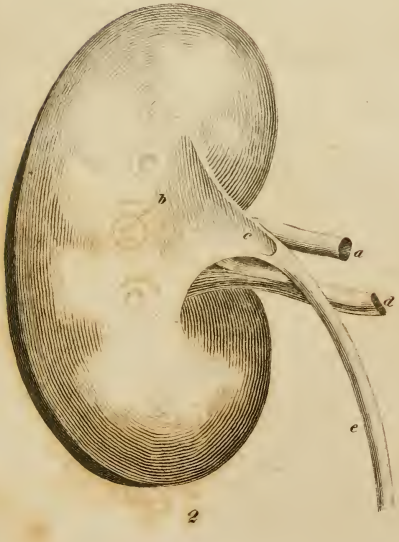

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PLATE VI.

BONES OF THE ARM.

Fig. 1. *a*, the *humerus:* the head, *b*, is a portion of a sphere, and exhibits an example of the *ball and socket*, or universal joint; *c*, the *hinge-joint*, instanced in the elbow; *d*, the *radius; e*, the *ulna.* The radius belongs more peculiarly to the wrist, being the bone which supports the hand, and which turns with it in all its revolving motions. The ulna principally belongs to the elbow-joint; for by it we perform all the actions of bending or extending the arm.

Fig. 2. *a*, the humerus: *b* shows the connection of the radius, with, *c*, the ulna, at the elbow. The mode of articulation at the wrist is seen, Fig. 1.

PLATE VII.

THE HIP, KNEE, AND ANKLE JOINTS.

Fig. 1. The capsular ligament is here opened in order to show the ligament of the hip, named the *round ligament.* It allows considerable latitude of motion, at the same time that it is the great safeguard against dislocation.

Fig. 2 and 4. The *crucial* or *internal ligaments* of the knee-joint arise from each side of the depression between the condyles of the thigh-bone; the anterior is fixed into the centre, the posterior into the back of the articulation of the tibia. This structure properly limits the motions of the joint, and gives the firmness requisite for violent exertions. Viewing the form of the bones, we should consider it one of the weakest and most superficial; but the strength of its ligaments and the tendons passing over it, render it the most secure, and the least liable to dislocation, of any joint in the whole body.

Fig. 3. One of the *interarticular* cartilages of the knee, from their shape called *semilunar;* it is also represented *in situ,* Fig. 2. The outer edge of each cartilage is thick, the inner concave edge thin; the sockets for the condyles of the thigh-bone are thus rendered deeper, and the cartilages are so fixed as to allow a little play on the tibia, by which the joint moves with great freedom.

A moving cartilage is not common, but is peculiar to those joints whose motions are very frequent, or which move under a great weight. It is a contrivance found at the jaw-bone, the inner head of the collar-bone, and the articulation of the wrist, as well as at the knee. The obvious use is to lessen friction and facilitate motion.

Fig. 4. *a,* the *fibula; b,* the *tibia,* the lower extremities of which, *c, d,* form the outer and inner ankle, and receive, *e,* the great articulating bone of the foot, called the *astragalus,* between them. When the foot sustains the weight of the body, the joint is firm; but when raised, it easily rolls on the ends of these bones, so that the toe is directed to the place on which we intend to step.


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PLATE VIII.

THE SPINE.

Fig. 1. The *human spine*, so named from the series of sharp processes projecting from the posterior part of the vertebræ. The spine consists of *seven* vertebræ of the neck, distinguished by the perforations in their transverse processes; of *twelve* belonging to the back, and marked by depressions for the heads of the ribs; and, lastly, of *five* belonging to the loins, which are larger than the other vertebræ.

Fig. 2. A separated *dorsal vertebra: a*, the body of the vertebra; *b*, the ring through which the spinal marrow passes; *c, c*, the articulating surfaces to which the ribs are united.

Fig. 3. The vertebra of a very large serpent, drawn from a specimen belonging to the Anatomy School of Christ Church, Oxford. This figure shows the socket of the vertebra.

Fig. 4. The ball or rounded joint, evidently calculated for extensive motion.

Fig. 5. A part of the spine of the same reptile; it is exceedingly strong, each bone being united to the other by fifteen surfaces of articulation.

Fig. 6. Intervertebral substance.

PLATE IX.

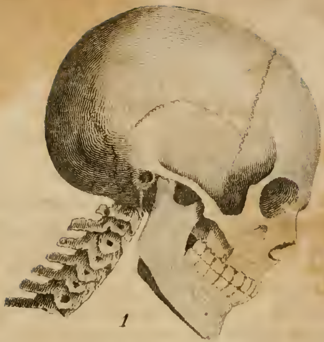
VERTEBRÆ OF THE HUMAN NECK.

Fig. 1. A representation of the head and the neck; the latter is composed of seven bones, called *vertebræ.*

Fig. 2. Exhibits the first and second vertebræ, with their mode of connection. The uppermost vertebra, termed the *atlas*, from its supporting the globe of the head, has an oval, *concave* surface, *a, a*, on either side, for the reception of two corresponding *convex* surfaces placed on the lower part of the head, in such a manner as only to admit of the action of bending and raising the head.

Fig. 3. The *atlas.*

Fig. 4. The second vertebra, called *dentata*, has two plane surfaces, *a, a*, adapted to the planes, *a, a*, Fig. 3, of the atlas; and this manner of articulation provides for the turning of the head laterally in almost every direction. Fig. 2, and 4, *b, b*, show the *tooth-like process*, which affords a firm pivot for the production of the lateral motion just described. This process is received into a corresponding *indentation* of the atlas, Fig. 3, *b*, and a strong ligament passes behind it, serving as an effectual security against dislocation and the consequent compression of the spinal marrow. Fig. 4, *d*, marks the situation for the spinal marrow, which passes through the ring of each vertebra. The letter *c* indicates a perforation in the lateral process; and, as there is a corresponding perforation in each lateral, or, as it is termed, *transverse* process of the seven *cervical* vertebræ, a continuous passage is thus formed for the protection of two important blood-vessels destined to supply the brain.



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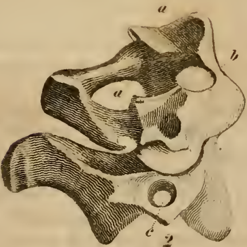

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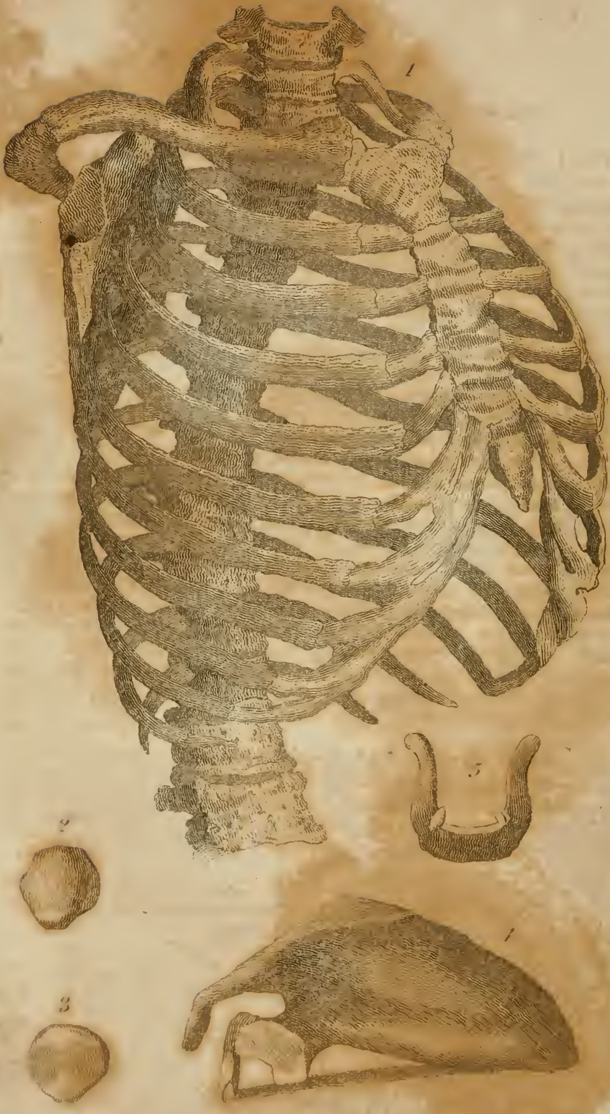

PLATE X.

THE CHEST, PATELLA, AND SHOULDER-BLADE.

Fig. 1. The *spine*, *ribs*, and *sternum*, constitute the framework of the *chest* or *thorax*. Referring, however, to the plate, or to nature, we observe that the ribs are not continued throughout from the spine to the sternum, but intervening *cartilages* complete the form of the chest, by connecting the end of the first ten ribs to the breast-bone. This is a further provision, relative to the mechanical function of the lungs, deserving notice. The muscles of respiration enlarge the capacity of the chest by elevating the ribs; and during the momentary interval of muscular action, the cartilages, from their great *elasticity*, restore the ribs to their former position.

Fig. 2. Represents the true shape of the *patella*, the *anterior surface convex*. Fig. 3, the *posterior surface*, which has two *concave* depressions adapted to the condyles of the thigh-bone. The projection of the patella, as a lever, or pulley, removes the acting force from the centre of motion, by which means the muscles have a greater advantage in extending the leg. Such bones are numerous, though less obvious, for they do not exceed the size of a pea: these are called *sesamoid bones*, and are formed in the flexor tendons of the thumb, and sometimes in the fingers. They are frequently found under the tendons of some of the muscles. Two of this sort of bones are constantly found under the articulation of the great toe with the foot: some also are discovered, though not so constantly, under the corresponding joints of the other toes. The sesamoid bones, like the patella, remove their tendons from the centre of motion, facilitate their glidings over the bone, and protect their articulations.

Fig. 4. The shoulder-blade (*scapula*) is joined to the collar-bone by ligaments, and to the thorax by powerful muscles, which are capable of sustaining immense weights, and whose action gives the various directions to the arm, and enables it freely to revolve at the shoulder-joint.

Fig. 5. The *os hyoides*, a small bone situated at the root of the tongue. It serves as a lever or point for attaching the muscles of the tongue, larynx, and those of deglutition.

PLATE XI.

THE HEART.

Fig. 1. A section of the human heart; *a*, *a*, the *superior* and *inferior vena cava*, the veins which convey the blood to, *b*, the *right auricle*, and thence into, *c*, the corresponding *ventricle;* from this ventricle the blood is impelled through, *e*, the *pulmonary artery*, into the lungs; and returning by, *f*, *f*, the *pulmonary veins*, it is received into, *g*, the *left auricle;* it flows next into, *h*, the *left ventricle*, which, by its contraction, distributes the blood through the general arterial system; *j*, the *aorta*, the great artery which transmits blood to the different parts of the body, from whence it is returned by veins to the *cavæ; k*, the *right subclavian; l*, the *right carotid* arteries, originating from one common trunk; *m*, the *left carotid; n*, the *left subclavian; d*, the *valves* of the right; *i*, the *valves* of the left ventricle.

Fig. 2. The valves of the right side (*tricuspid valves*) separated from the heart; *a*, *a*, *a*, the *columnæ carneæ*, or muscular fibres of the valves; *b*, *b*, *b*, the *chordæ tendineæ*, or tendinous filaments which are attached to, *c*, the valves.

Fig. 3. Exhibits the *pulmonary artery* cut open, with the form of the *semilunar valves.*

Fig. 4. A portion of the artery filled, showing how effectually the valves prevent the retrograde motion of the blood in the aorta and pulmonary artery.

Fig. 5, 6. A section of a cutting and grinding tooth, showing the apertures at the root, and the cavities for the vessels and nerves, which supply the bony part of the teeth, the enamel not being an organized substance.

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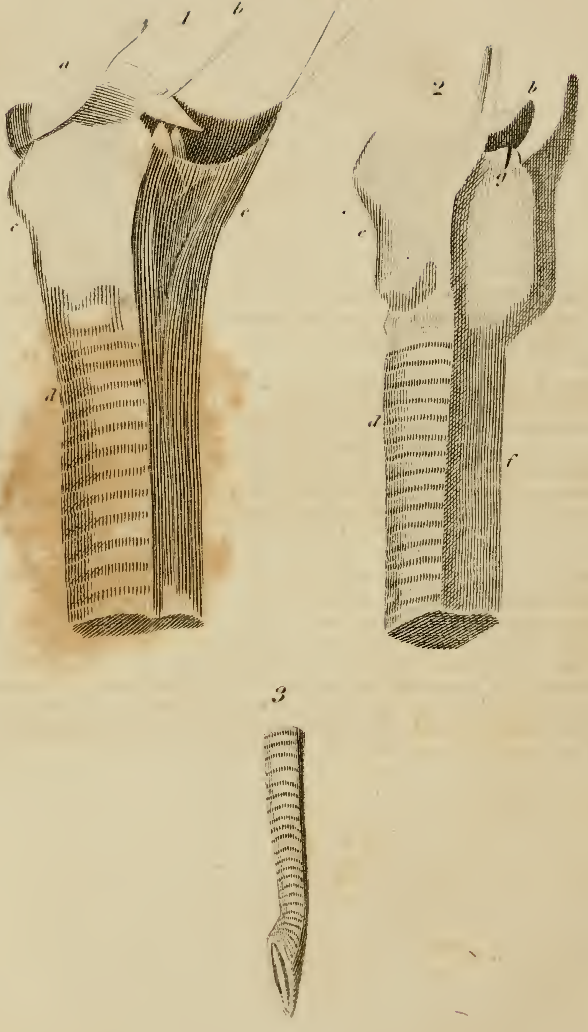
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PLATE XII.

THE LARYNX.

Fig. 1. The *larynx*, *pharynx*, &c.; *a*, the *os hyoides*; *b*, the *epiglottis* pressed down, thus covering the *glottis*, or opening of the *larynx*, as it does in the act of deglutition.

Fig. 2. Exhibits the *larynx* and *trachea*, which is a continuation of the former; *b*, the *epiglottis*; *g*, the *arytenoid cartilages*; *e*, the *thyroid cartilage*, exceedingly strong, for the protection of the upper part of the air-tube; *d*, the *cartilaginous ringlets* of the *trachea* or *windpipe*, each forming nearly two thirds of a circle, and completed by, *f*, a soft *membrane*, which, from its apposition to, *e*, Fig. 1, the *œsophagus*, accommodates itself to the substances passing into the stomach.

Fig. 3. The *larynx* or *upper* part of the windpipe of a bird. This is called the *inferior larynx*, where the vocal organ is formed by a compression of the trachea, for it is here contracted into a narrow chink, and divided into two openings by a slender bone, or tense membrane, which, in producing sounds, resembles the mechanism of a musical instrument. In the plate, this part of the larynx is a little turned up, to show the *tendinous band* at this extremity stretched across it, which is furnished from the surrounding parts with muscles to modulate the tone.

PLATE XIII.

THE STOMACH, GALL-BLADDER, &c.

Fig. 1. *a*, the *stomach ; b*, the *cardia ; c*, the *pylorus*. The *gastric juice* is a secretion derived from the inner membrane of the stomach, and digestion is principally performed by it. In the various orders of animated beings it differs, being adapted to the food on which they are accustomed to subsist. The food, when properly masti cated, is dissolved by the gastric fluid, and converted into *chyme ;* so that most kinds of the ingesta lose their specific qualities; and the chemical changes to which they would otherwise be liable, as putridity and rancidity, &c., are thus prevented.

In this plate, *h*, the *liver*, is turned up, in order to show the *gall-bladder*, which is attached to its concave surface; *d*, the *duodenum ; e*, part of the small *intestines ; f*, the *pancreas ;* and *g*, the *spleen*.

Fig. 2. Explains the several ducts and their communication with the *duodenum ; a*, the *gall-bladder ; b*, the *ductus cysticus ;* which uniting with, *c*, the *ductus hepaticus*, forms, *d*, the *ductus communis ;* which, after passing between the muscular and inner coats of the intestine, opens into it at *e ; f*, the *pancreatic duct*. The bile is said to become more viscid, acrid, and bitter, from the thinner parts being absorbed during its retention in the gall-bladder.

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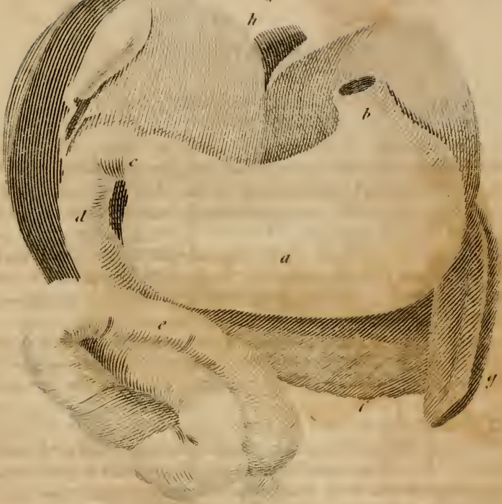

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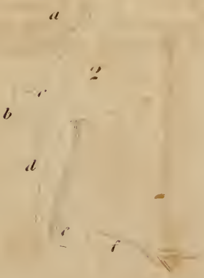

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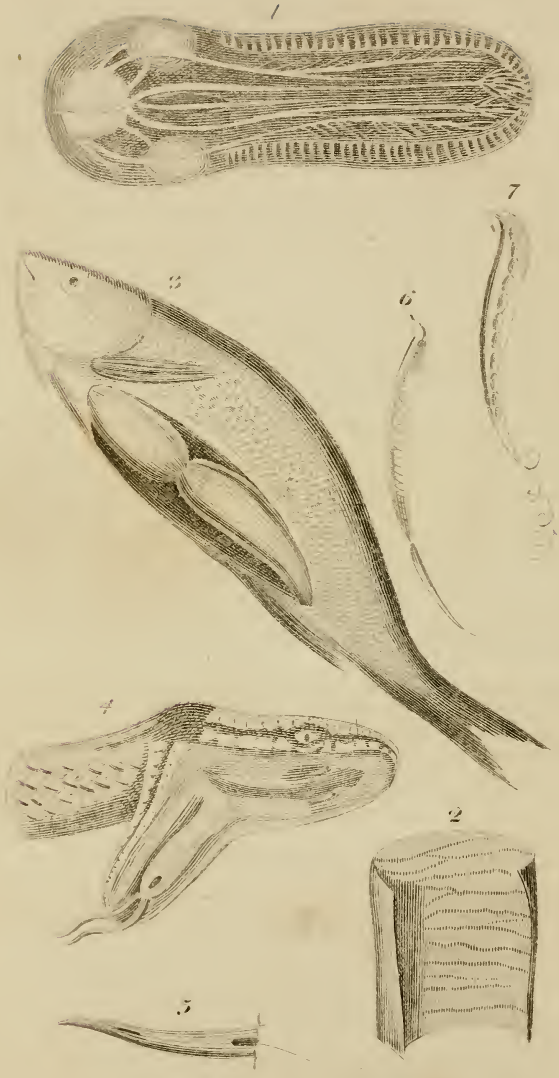


PLATE XIV.

NERVES OF THE BILL OF A DUCK, VALVULÆ CONNIVENTES, AIR-BLADDER OF A FISH, AND FANG OF THE VIPER.

Fig. 1. The upper *mandible* of the duck, on which are distributed the first and second branches of the fifth pair of nerves; the former passing through the orbit to the extremity of the bill, and, together with the latter, supplying the whole palatine surface. This gustatory sensibility is the more necessary to those races of birds called palmipedes, such as penguins, the wild goose, ducks, &c., and the grallæ, such as water-hens, curlews, woodcocks, &c., their sight being of no assistance to them in finding their prey in the mire.

Fig. 2. A small portion of the human intestine cut open in order to show the *valvulæ conniventes.* It may be questioned whether these extremely soft rugæ or folds of the villous coat of the intestine can in the least retard the passage of the food through its canal; nor does the erect attitude of man require them; for, since there are as many of the convolutions of the intestines ascending as there are descending, the weight of the food can have no influence in the action of the intestine: it is certain, however, that this arrangement of the internal coat affords *a more extensive surface for the lacteals and secreting vessels;* and this appears to be the real use of the *valvulæ conniventes.*

Fig. 3. The *air-bladder* in the roach. This vessel differs in size and shape, in different species of fish; generally communicating, by one or more ducts, either with the œsophagus or stomach; by which means the fish receives or expels the air, thus sinking or rising without effort: but as some are destitute of this organ, it is considered as an accessory instrument of motion. Such fish live almost uniformly at the bottom of the water.

Fig. 4. The head of a viper, of the natural size.

Fig. 5. The *fang* magnified, at the root of which is the gland which secretes the venom: a hair is represented in the tube through which the poison is ejected.

PLATE XV.

THE WINGS OF THE BEETLE, AWL, STING OF THE BEE, PROBOSCIS, &C.

FIG. 1. Is an instance of the horny and gauze wings in one of the most beautiful of the beetle class of this country, the *Cetonia aurata*, or rose chafer; showing the expanded *elytra*, *a*, *a*; the true wings, *b*, *b*.

Elytra are the wing covers of all the *coleoptera* order. They are frequently grooved, and curiously ornamented, in some species with scaly variegations of metallic lustre, as in the diamond beetle, and some species of Buprestis. One of the latter, of extraordinary brilliancy, forms an object in the "Cabinet of Beauty" in the Ashmolean Museum. The use of the elytra is to protect the wings and body; and they are of some assistance in flying.

FIG. 2. A specimen of the elytra covering half the body in the *ear-wig* (Forficula auricularia); one of the elytra is extended, and the membranous wing unfolded; showing the numerous diverging *nervures*, or muscular tendons, which run in horny tubes, to keep the wing extended. *a*, *a*, *antennæ* usually consist of a number of tubular joints, with a free motion in each, enabling the insect to give them every necessary flexure; they vary in number and in shape in the various orders, and are covered with hair, down, or bristles, frequently elegant and diversified, as every one may observe. Entomologists conceive, that the antennæ, by a peculiar structure, may collect notices from the atmosphere, receive vibrations, and communicate them to the sensorium, which, though not precisely to be called hearing, is something analogous to it, or may answer that purpose.

FIG. 3. The *awl* of the *Æstrum bovis*, or *gad-fly*, highly magnified. It is formed of corneous substance, consisting of four joints, which slip into each other: the last of these terminates in five points, three of which are longer than the others, and are hooked; when united, they form an instrument like an auger or gimlet, with which the skin is pierced in a few seconds.

FIG. 4. One of the *hooks*.

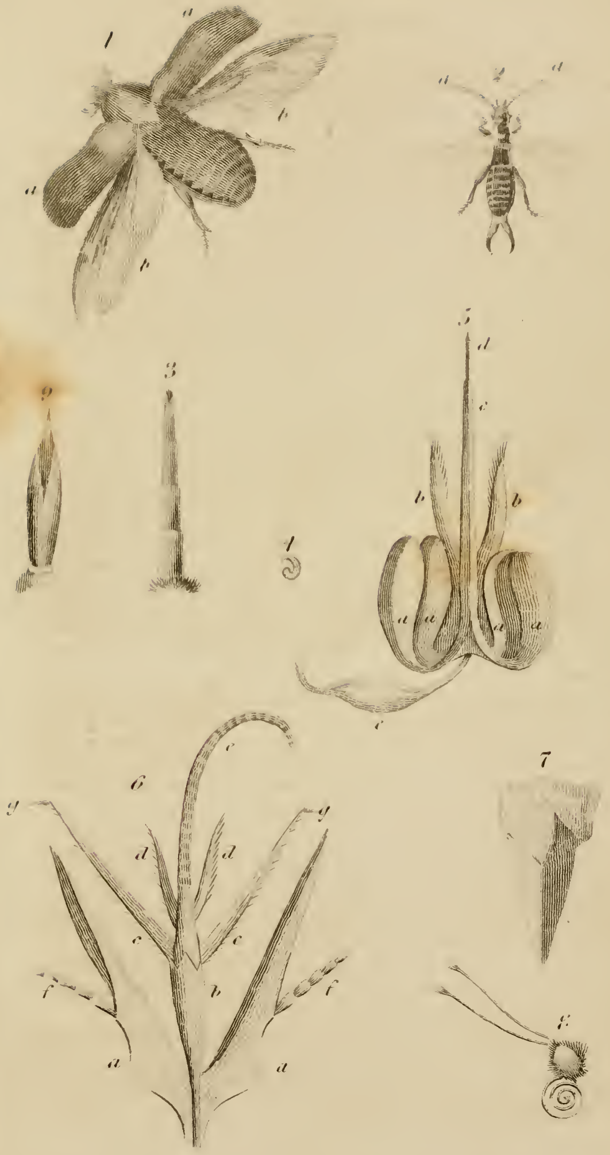
FIG. 5. The *sting of a bee*, drawn from nature as it appears by means of a magnifier of very high powers; *a*, *a*, *a*, *a*, the appara tus for projecting the sting; *b*, the exterior, *c*, the interior sheath of, *d*, the *true sting*, which is divided into two parts, barbed at the sides; *e*, the bag which contains the *poison*.

FIG. 6. The *proboscis* of a bee extended; *a*, *a*, the case or sheath; *b*, the tube; *c*, the exterior, *d*, the interior fringes; *e*, the tongue; *f*, *f*, the exterior, *g*, *g*, the interior palpi.

FIG. 7. The appearance of the proboscis when contracted, and folded up.

FIG. 8. The head of a butterfly, showing the *coiled proboscis*.

FIG. 9. *Ovipositor* of the *Buprestis*.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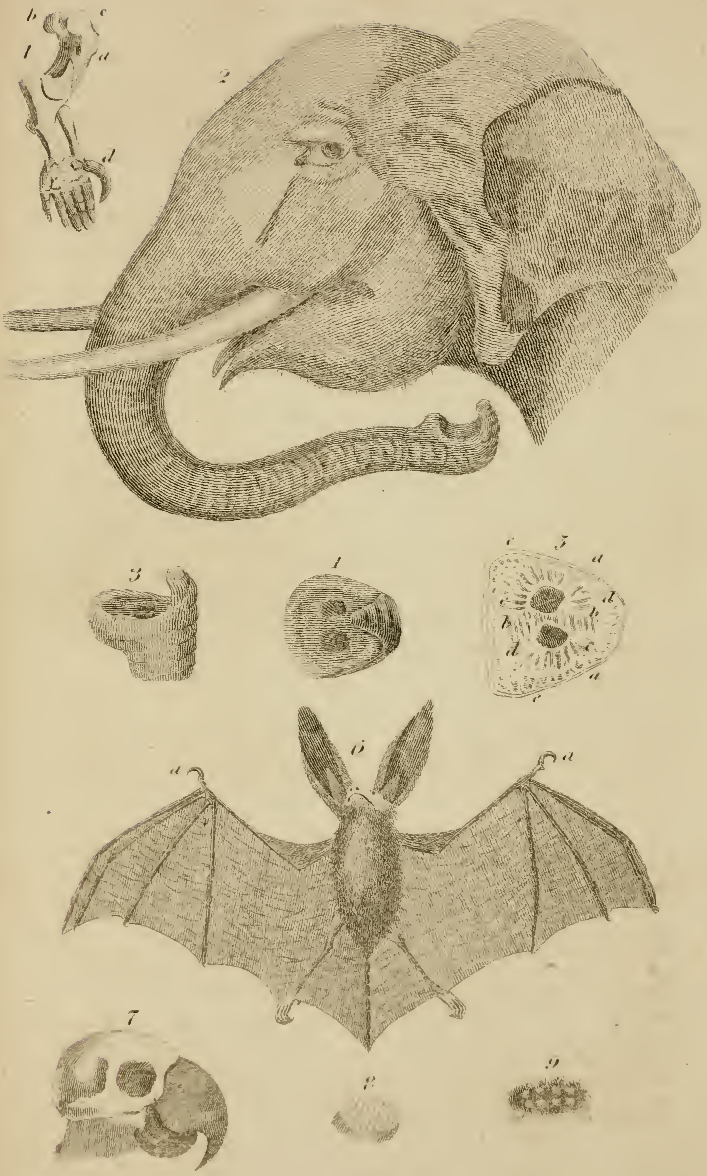
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PLATE XVI.

FORE EXTREMITY OF THE MOLE—HEAD OF THE ELEPHANT—FINGER-LIKE EXTREMITY OF THE PROBOSCIS—SECTION OF THE PROBOSCIS—BAT'S WING—BILL OF THE PARROT—EYES OF INSECTS—EYES OF A SPIDER.

Fig. 1. Is the fore extremity of the *mole ;* *a*, the *os humeri*, is peculiar, not only for its shortness, but in being articulated by, *b*, one head to the scapula, and by, *c*, another to the clavicle; it is altogether of such a nature as to turn the palm outwards for working.

The foot, or we may name it the hand, has eleven bones in the *carpus*, or wrist, which is two more than the carpus of man; one of which, *d*, is remarkable, and from its shape is called the *falciform bone:* it gives the shovel form to the hand.

Fig. 2. The head of the *Elephant*.

Fig. 3 and 4. The digitated extremity of the proboscis.

Fig. 5. A transverse section of the proboscis, showing, *a*, *a*, the two tubes or nostrils. Between the external integuments and the tubes are two sets of small muscles; an inner one running in a transverse, and an outward one in a longitudinal direction: *b*, *b*, the *transverse* fasciculi of muscles, some of which run across the proboscis, others in a radiated, and some in an oblique direction: *c*, *c*, the radiated, and *d*, *d*, the oblique fibres approximate the skin and the tubes, without contracting the cavity of the latter. The others, which pass across the proboscis, contract both the surface of the organ and the canals it contains; they can, at the same time, elongate the whole or a part of it; *e*, *e*, the *longitudinal* fasciculi, forming four large muscles, which occupy all the exterior of the organ.

Fig. 6. The extended wings of the *bat*. Osteologically considered, they are hands, the bony stretches of the membrane being the finger bones extremely elongated: *a*, *a*, the thumb, is short, and armed with a hooked nail, which these animals make use of to hang by, and to creep. The hind feet are weak, and have toes of equal length, armed also with hooked nails; the membrane constituting the wing, is continued from the feet to the tail.

Fig. 7. The upper *mandible* of the *parrot*, which is articulated with the cranium by an elastic ligament, admitting of a considerable degree of motion.

Fig. 8. An eye compounded of a number of lenses. The eyes of insects differ widely from those of vertebrated animals, by being incapable of motion: the compensation, therefore, is a greater number of eyes, or an eye compounded of a number of lenses. Hook computed the lenses in a horse-fly to amount to 7,000, and Leuwenhoek found the almost incredible number of 12,000 in the dragon-fly.

Fig. 9. The eyes of a *spider*, drawn from nature. The number of eyes in insects varies from two to sixteen. The spider here referred to, answers the description of the garden spider (*Epeira diadema*), the eyes of which are planted on three tubercles, four on the central one, and two on each side of the lateral ones.

PLATE XVII.

THE PAROTID GLAND.

Fig. 1. A dissection to exhibit the *parotid gland.*

Fig. 2. Explains the former; *a, a,* the integuments turned back; *b,* the *parotid gland;* *c,* its *pipe* or *duct* passing over the *masseter,* then perforating, *d,* the *buccinator muscle,* and opening into the mouth opposite the second molar tooth. The flow of saliva into the mouth is incessant, and it is one of the most useful digestive fluids. It is favorable to the maceration and division of the food; it assists in its deglutition and transformation into chyme; it also renders more easy the motions of the tongue in speech and singing.

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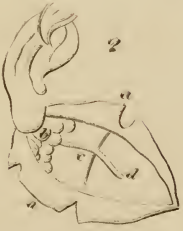


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PLATE XVIII.

TONGUE OF THE WOODPECKER, AND SKULL OF THE BABYROUESSA.

Fig. 1. The *head of the woodpecker* (*Picus viridis*).

Fig. 2. The *tongue*, the natural size.

Fig. 3. The claw of the same bird.

Fig. 4. The *skull of the Babyrouessa*, from a specimen in the Anatomy School, Christ Church, Oxford.

This animal is nearly the size of the common hog, and, instead of bristles, is covered with fine short and woolly hair, of a deep brown or black color. It is also distinguished by the extraordinary position and form of the *upper tusks*, which are not situated on the edge of the jaw, as in other animals, but are placed externally, perforating the skin of the snout, and turning upwards towards the forehead.

The Babyrouessa is found in large herds in many parts of Java, Amboyna, and other Indian islands, and feeds on vegetables.

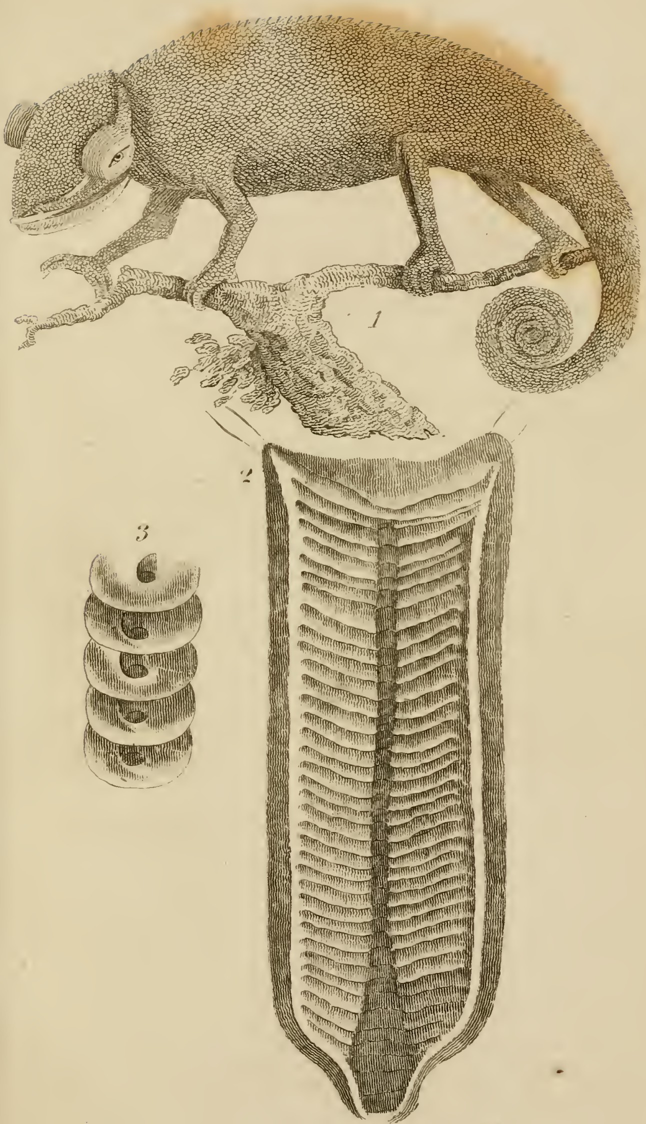
PLATE XIX.

THE CHAMELEON, AND INTESTINE OF THE SEA-FOX.

FIG. 1. The *chameleon*, drawn from one of the specimens preserved in the Anatomy School, Christ Church, Oxford. The eyes of this creature are very peculiar: they are remarkably large, and project more than half their diameter. They are covered with a single eyelid, with a small opening in it opposite the pupil. The eyelid is granulated like every part of the surface of the body, with this difference; over the eye the granulations are disposed in concentric circles which form folds in that part to which the eye is turned; and as the lid is attached to the front of the eye, so it follows all its movements. The neck is not inflexible, but its shortness, and the structure of the cervical vertebræ exceedingly limit the motion: this, however, is admirably compensated by the not less singular local position than motion of the eye, as the animal can see behind, before, or on either side, without turning the head.

FIG. 2. The spiral intestine of the *sea-fox* cut open; taken from a preparation in the museum of the Royal College of Surgeons, London. The sea-fox is a species of shark (*Squalus vulpes*). The convoluted intestinal tube is also found in some other genera of fish. In this specimen the internal membrane is converted into a spiral valve, having thirty-six coils; so that the alimentary substances, instead of passing speedily away, by proceeding round the turns of the valve, traverse a very considerable circuit: an extensive surface for the absorbents is thus provided.

FIG. 3. The *spiral valve* removed, showing the mode of its coiling.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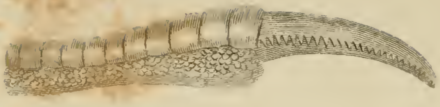

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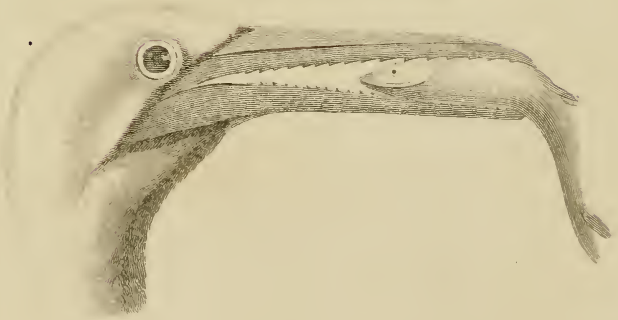

PLATE XX.

CLAW OF THE HERON, AND BILL OF THE SOLAND GOOSE.

FIG. 1. The *middle claw of the heron.*

FIG. 2. The head of the *soland goose* (*Pelecanus bassanus*), drawn from a specimen in the Ashmolean Museum, Oxford. This bird inhabits the coldest parts of Great Britain, more especially the northern isles of Scotland. The inhabitants of St. Kilda make it their principal article of food, and are said to consume annually near 30,000 young birds, beside an amazing quantity of eggs.

PLATE XXI.

STOMACH OF THE CAMEL.

The figure in this plate exhibits the *cells in the stomach of the camel*, from a preparation in the museum of the Royal College of Surgeons, London. In the camel, dromedary, and lama, there are four stomachs, as in horned ruminants; but the structure, in some respects, differs from those of the latter. The camel tribe have, in the first and second stomachs, numerous cells several inches deep, formed by bands of muscular fibres crossing each other at right angles: these are constructed so as to retain the water, and completely exclude the food. In a camel dissected by Sir E. Home, the cells of the stomach were found to contain two gallons of water; but in consequence of the muscular contraction, which had taken place immediately after death, he was led to conclude this was a quantity much less than these cavities were capable of receiving in the living animal. See Lectures on Comparative Anatomy, by Sir E. Home, vol. i. p. 168.

Mr. Bruce states, in his Travels, that he procured four gallons of water from a camel, which from necessity he slaughtered in Upper Egypt.

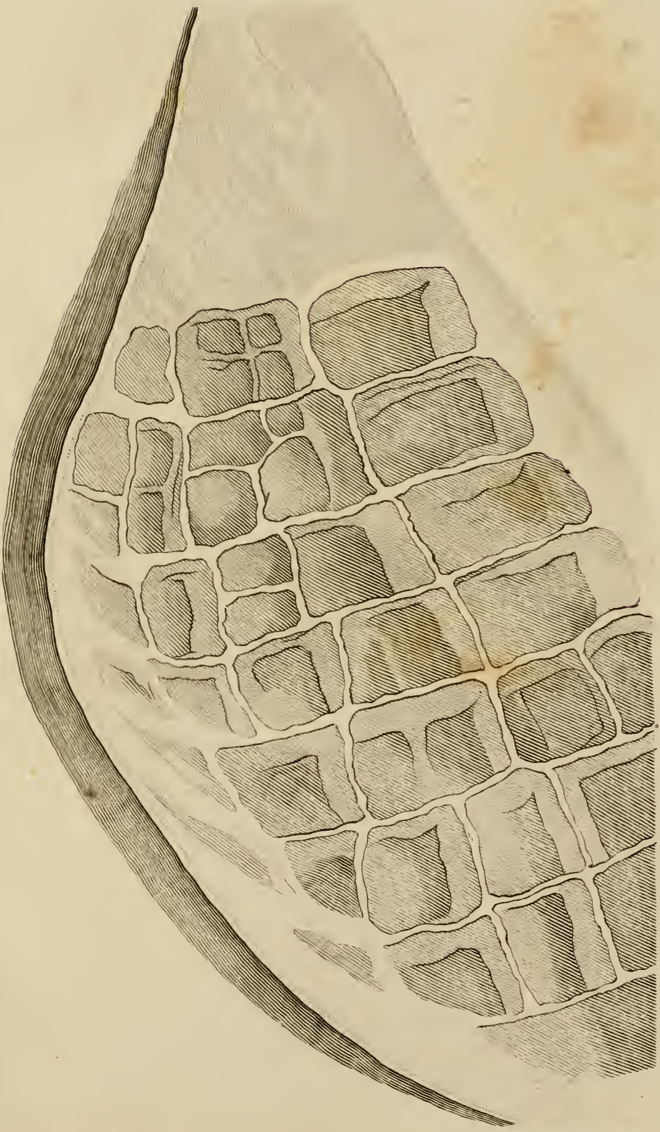


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PLATE XXII.

SILK SECRETORS OF THE SILK-WORM—SPINNERETS OF THE SPIDER—PANORPA COMMUNIS—FEMALE AND MALE GLOW-WORM—LARVA LIBELLULÆ—BREATHING SPIRACULÆ—PUPA OF GNAT—STRATYOMYS CHAMÆLEON.

FIG. 1. The organs for forming the silk consist of two long vessels. They unite to form the *spinneret* (fusulus), through which the larva draws the silken thread employed in fabricating its cocoon. *a, a,* the *silk bags; b,* the *spinneret.*

FIG. 2. The web of spiders is also a kind of silk, remarkable for its lightness and tenuity; it is spun from four or six spinnerets, the fluid matter forming the web being secreted in adjacent vessels. *a, b, c, d,* the *spinnerets.*

FIG. 3. *Panorpa communis* (Linn.) is an insect frequently seen in meadows during the early part of summer. It is a long-bodied fly, of moderate size, with four transparent wings, elegantly variegated with deep brown spots.

FIG. 4. The female glow-worm.

FIG. 5. The male of the same insect.

FIG. 6. The larva of some dragon-flies (*Æshna* and *Libellula, F.*) swim by strongly ejecting water. By first taking in the water, and then expelling it, they are enabled to swim. This may be seen by putting one of these larvæ into a plate with water. We find that while the animal moves forward, a current of water is produced by this pumping in a contrary direction. Sometimes it will raise its tail above the surface, when a stream of water issues from it.

FIG. 7. The *spiraculæ*, or breathing pores of insects, are small orifices in the trunk or abdomen, opening into canals called the *tracheæ*, by which the air enters the body, or is expelled from it. In the larvæ or caterpillars, a trachea runs on each side of the body, under the skin, and generally opens externally by nine or ten apertures or spiraculæ; from these the same number of air-vessels, of a silver color, pass off to be dispersed through the body. *a, a, spiraculæ; b, b, tracheæ.*

FIG. 8. The pupæ of gnats suspend themselves on the surface of the water, by two ear-shaped respiratory organs at the posterior extremity of the body, the breast being doubled upwards upon the abdomen. When disposed to descend, the animal unfolds it, and with sudden strokes which she gives with it, she swims from right to left, as well as upwards and downwards, with the greatest ease.

FIG. 9. This is a well-known fly (*Stratyomys chamæleon, F.*), chameleon-fly. In its first state it inhabits the water, and often remains supported by its radiated tail, consisting of beautiful feathered hairs or plumes, on the surface, with its head downwards. But when it is disposed to seek the bottom, or to descend, the radii of the tail are formed into a concavity including in it an air-bubble; this is its swim-bladder, and by the bending of its body from right to left, contracting itself into the form of the letter S, and then extending itself again into a straight line, it moves itself in any direction.

PLATE XXIII.

THE CAPSULE, PISTIL, STAMENS, NIGELLA, PLUMULA, AND RADICLE.

FIG. 1. The *capsule* or seed-vessel of the poppy (*Papaver somniferum*): it is divided to exhibit its internal structure.

FIG. 2. Is an instance of an erect flower, the *Agave Americana*, in which the pistil is shorter than the stamens. *a*, the pistil; *b*, the stigma; *c*, the stamens; *d*, the anthers.

FIG. 3. A flower of the *crown imperial* (*Fritillaria imperialis*). The relative length of the parts is now inverted. *a*, the pistil; *b*, the stamens.

FIG. 4. A blossom of the *Nigella*.

FIG. 5. A grain of barley, showing the *plumula* and *radicle growing from it.*


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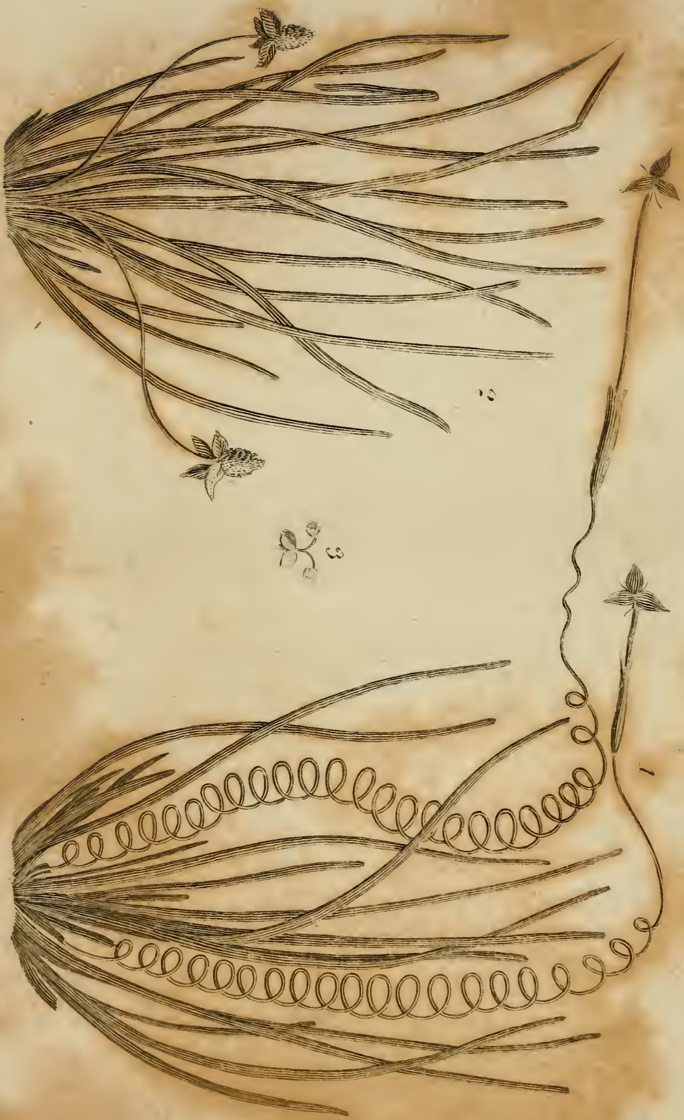
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PLATE XXIV.

VALLISNERIA.

Fig. 1. *Vallisneria spiralis.* The *female plant*, the flowers of which are purple.

Fig. 2. The *male plant*, producing white flowers: these when mature rise like air-bubbles, and, suddenly expanding when they reach the surface of the water, float about in such abundance as to cover it entirely. "Thus their pollen is scattered over the stigmas of the first-mentioned blossoms, whose stalks soon afterwards resume their spiral figure, and the fruit comes to maturity at the bottom of the water."

Fig. 3. One of the separated *male* flowers magnified.

PLATE XXV.

TEMPORARY AND PERMANENT TEETH.

Fig. 1. The gums and outer plate of the bone are removed, showing the teeth of the infant, as they exist at the time of its birth: they are without roots, and contained in a capsule within the jaws.

Fig. 2. In this figure, also, the outer alveolar plate of the jaws has been removed to show the succession of teeth. This is the state at six years of age. The *temporary* teeth are all shed between the ages of seven and fourteen, and are supplied by the *permanent teeth*, already nearly perfectly formed, and situated at the roots of the former.

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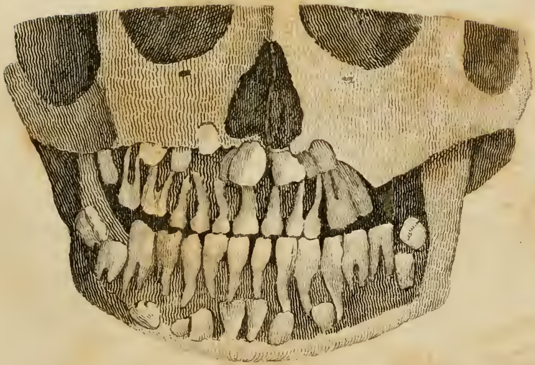

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PLATE XXVI.

THE TENDONS OF THE TOES.

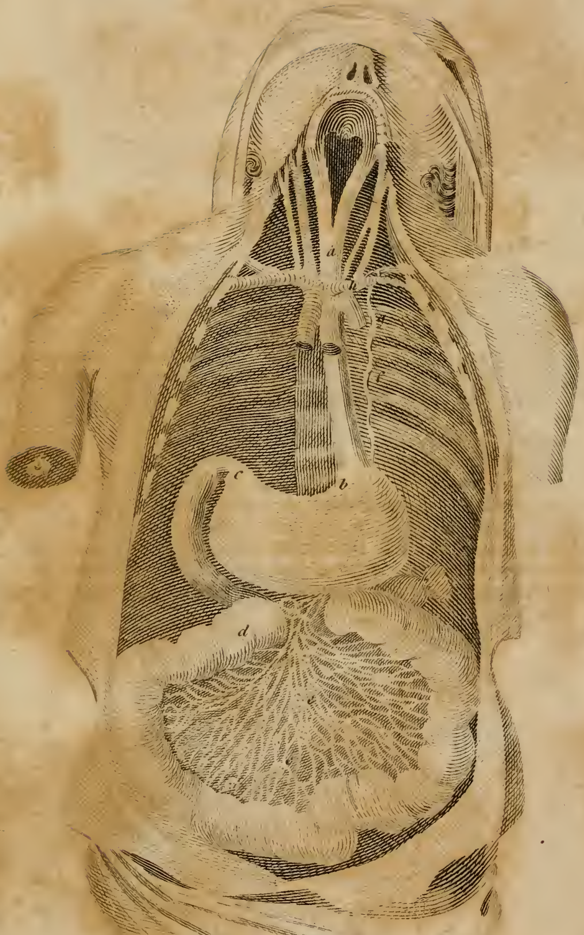
Fig. 1. *a*, the tendon of the *long flexor of the toes*, which divides about the middle of the foot into four portions, passing through the slits in, *b*, the *short flexor tendons*. Fig. 2. explains a similar contrivance belonging to each finger: *a*, a tendon of the *flexor sublimis;* *b*, a tendon of the *flexor profundus*, passing through it.

Fig. 3. *a*, *b*, tendons of the extensor muscles of the toes; *c*, a tendon of a flexor of the foot. These are bound down and retained *in situ* by, *e*, the *annular ligament* of the instep, which consists of two distinct cross bands, going from the outer ankle to the inner ankle and neighboring bones.

PLATE XXVII.

THE LACTEALS, AND THORACIC DUCT.

The figure in this plate represents the course of the food, from its entrance at the mouth to its assimilation with the blood: *a*, the *œsophagus*, extending from the *pharynx* to, *b*, the *stomach;* where the alimentary matter, having undergone the digestive process, is converted into *chyme*, a soft, homogeneous substance, and escapes at *c*, the *pylorus*, into *d*, the *intestines*. In this plate a large portion of the latter is spread out, to show a part of the absorbent system called *lacteals:* these collect and imbibe the *chyle*, or milky juice from the chyme, and transmit it through *e*, *e*, the *mesenteric glands*, into one general receptacle, *f* (*receptaculum chyli*), from which, *g*, the *thoracic duct* ascends, in a more or less tortuous direction, to the lower vertebræ of the neck, and after forming an arch, it descends and enters, *h*, the left *subclavian vein*, at the point where that vein is united with the *internal jugular*. The absorbents of the right side frequently form a trunk, which enters the *right subclavian vein*.


a
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Gould, Kendall, & Lincoln's Publications.

THE ORIGIN AND HISTORY OF MISSIONS; a Record of the Voyages, Travels, Labors, and Successes of the various Missionaries, who have been sent forth by Protestant Societies and Churches to evangelize the Heathen; compiled from authentic Documents; forming a complete MISSIONARY REPOSITORY; illustrated by numerous Engravings, from original Drawings made expressly for this Work. By the Rev. JOHN O. CHOULES, New Bedford, Mass., and the Rev. THOMAS SMITH, late Minister of Trinity Chapel, London. Fourth Edition, continued to the present time.

The original cost of the stereotype plates, engravings, &c., to this work, considerably exceeded $7000, which necessarily so enhanced the price of former editions ($13 per copy), that many were precluded from purchasing it, who would otherwise have gladly done so.

The present proprietors, having purchased the work at a considerable deduction from cost, and being desirous of placing it within the reach of *every one* wishing to possess this valuable repository of missionary intelligence, have determined to put it at the *very low price* of $7 per copy, trusting that by this means it will receive from an enlightened Christian community the *extensive patronage* which the merits and importance of the work demand.

RECOMMENDATIONS.

The plan and object of the ORIGIN AND HISTORY OF MISSIONS having been submitted to us, we beg leave most cordially to recommend it to the attention of the religious public, considering it highly calculated to extend the interest which is already felt on behalf of the great missionary enterprise.

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[Extract from the Report of the Committee of the Baptist General Convention on Publications.]

The Origin and History of Missions, by the Rev. J. O. Choules, having been referred to the notice of this Committee, they have fully examined the number already printed, and possessed themselves of the views of the conductors of the work. The Committee are happy to express their entire confidence in the qualifications of the author, and belief that the work will richly merit the attention of the religious public.

MAMMON; (Prize Essay;) or, Covetousness the Sin of the Christian Church. By Rev. John Harris, Author of the "Great Teacher." Second American, from the Tenth London Edition.

This work has already engaged the attention of churches and individuals, and receives the highest commendations. The publishers take pleasure in presenting the following united recommendation from clergymen in this city:—

Having read the Prize Essay of the Rev. John Harris, entitled "Mammon, or Covetousness the Sin of the Christian Church," we cordially recommend it as deserving the serious perusal of the professed followers of Christ.

Its general circulation will be a powerful means of increasing the spirituality of the churches, and of advancing every good work which depends in any measure upon pecuniary contributions.

R. Anderson,	J. H. Fairchild,
David Greene,	S. S. Mallery,
Daniel Sharp,	Hubbard Winslow,
Wm. M. Rogers,	Lucius Bolles,
Jotham Horton,	Abel Stevens,
Baron Stow,	Wm. Jenks,
Wm. Hague,	A. Boies,
George B. Ide,	D. M. Lord,
Geo. W. Blagden,	E. Thresher.

[From the Christian Watchman.]

We wish not only to add our testimony to the excellency of this book, but to urge it upon the attention of our readers. We commend it to the attention of business men, and especially young men.

[From the New York Observer.]

We have read this work with great interest, and recommend it as equally rich in evangelical principle, philosophical analysis, and practical application.

[From the Philadelphia Observer.]

This neat little volume, on the important subject of which it treats, we have read with much satisfaction. The author handles it in a masterly manner. * * * Our hope is, that it will be extensively read.

[From Zion's Herald.]

Among all the books which have fallen into our hands to notice, we have never felt our inability to do justice to any of them, to such an extent as to the one now before us. It exhibits the writer as a man of superior intellectual power, and gifted with talents which, if rightly applied and heeded, may yet be destined to move the moral world. His eloquence is the eloquence of reason, founded in the records of eternal truth. His sentiments are a wonderful concentration of truth and wisdom, carrying with them such convincing power, as must strip avarice of its coat of mail, and turn the streams of extravagance into the channel of universal love. His style is so entirely free of cumbrous words, that the whole book resembles a series of epigrammatical sentences, each one conveying, in a few lines, that for which, in many writers, we have to travel over pages.

[From the Southern Religious Telegraph.]

Its appearance is highly seasonable. Its title may appear repulsive to some members of the church. *Mammon!* Who is willing to be recognized as a disciple of Mammon? * * * The power and spirit in which it is written, the noble thoughts of the writer, nobly expressed, will commend it to their attention, and they will read and admire it, even if they decide that they will not repent.

[From the Biblical Recorder, Newburn, N. C.]

The extent and ruinous consequences of the sin of which this work treats, even among professors of religion, we have long been fully apprized of. The publication of the above-named work in this country, we therefore consider seasonable and happy.

[From the Richmond Religious Herald.]

The work attacks with much force this insidious vice. Mr. Harris is a fearless and energetic writer. His style is close, nervous and lucid, and his habits of thinking highly original. The topics he selects are judiciously selected, and impressively enforced. The present treatise has fully answered our expectations; and we earnestly trust it will be extensively read, and be productive of much good.

[Extract from an extended Notice in the Christian Review.]

We hail this volume with heartfelt pleasure. Its appearance is most seasonable. It will commend itself to all who will peruse its pages; and we trust that its solemn and powerful appeals to conscience and duty may be productive of the happiest results. We do earnestly advise the pastors of churches to take pains to promote the circulation and perusal of this *masterly production* among their congregations.

[A correspondent of the Boston Recorder says,]

O that Christian professors generally could be induced to read, with a teachable spirit, this pungent, soul-stirring appeal, and then examine how clearly and frequently the Scriptures place the *covetous* with "idolaters," who "have no inheritance in the kingdom of Christ and of God."

New and Improved Edition.

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LATE MISSIONARY TO BURMAH,

CONTAINING MUCH INTELLIGENCE RELATIVE TO THE BURMAN MISSION.

BY REV. ALONZO KING, OF NORTHBORO', MASS.

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[From Rev. J. O. Choules, of New Bedford.]

I have read the Memoir of Boardman with great satisfaction. * * * The great charm in the character of Mr. Boardman was his fervent piety; and his biographer has succeeded admirably in holding him up to the Christian world as the pious student, the faithful minister, and the self-denying, laborious missionary. To the student, to the Christian minister, it will be a valuable book, and no Christian can peruse it without advantage. I hope our ministering brethren will aid in the circulation of the Memoir. Every church will be benefited by its diffusion among its members. Yours, &c., JOHN O. CHOULES.

[From the Christian Watchman.]

This Memoir belongs to that small class of books, which may be read with interest and profit by every one. It comprises so much of interesting history; so much of simple and pathetic narrative, so true to nature; and so much of correct moral and religious sentiment, that it cannot fail to interest persons of all ages and of every variety of taste.

[From Rev Baron Stow.]

No one can read the Memoir of Boardman, without feeling that the religion of Christ is suited to purify the affections, exalt the purposes, and give energy to the character. Mr. Boardman was a man of rare excellence, and his biographer, by a just exhibition of that excellence, has rendered an important service, not only to the cause of Christian missions, but to the interests of personal godliness.

Yours, with esteem, BARON STOW.

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LATE MISSIONARY TO BURMAH.

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BY JAMES D. KNOWLES,

Professor of Pastoral Duties in the Newton Theological Institution.

EMBELLISHED WITH ENGRAVINGS.

Twenty-five thousand copies of this work have been sold in the United States, besides several editions in England. It has also been printed in French, and is about to be published in the German language; which shows that it is a work of no *ordinary* interest.

[Extract from Mrs. Hale's Ladies' Magazine.]

We are glad to announce this work to our readers. The character of Mrs. Judson is an honor to American ladies. The ardent faith that incited her to engage in an enterprise so full of perils; the fortitude she exhibited under trials which it seems almost incredible a delicate woman could have surmounted; her griefs, and the hopes that supported her, should be read in her own expressive language. Her talents were unquestionably of a high order; but the predominant quality of her mind was its energy. The work contains, besides the life of Mrs. Judson, a History of the Burman Mission, with a sketch of the Geography, &c., of that country, and a Map accompanying, and a beautifully engraved portrait of Mrs. Judson.

[From the London New Baptist Miscellany.]

This is one of the most interesting pieces of female biography which has ever come under our notice. No quotation, which our limits allow, would do justice to the facts, and we must therefore refer our readers to the volume itself. It ought to be immediately added to every family library.

MEMOIR OF REV. WILLIAM CAREY, D. D., forty Years Missionary in India. By Rev. EUSTACE CAREY. With an Introductory Essay, by FRANCIS WAYLAND, D. D., President of Brown University. With a correct Likeness.

[From the Monthly Paper of the Baptist General Tract Society.]

This is a work of surpassing interest, which no Christian can read without profit. The mechanical execution is excellent, and reflects much credit on the enterprising publishers. They have given to the American public an imperishable work, that will be perused with intense interest by generations yet unborn.

We have seldom, if ever, read a book which has impressed us with such a conviction of the importance of its being most extensively circulated. With the Memoir of our own Mrs. Judson, it ought to have a place in every family and in every library.

[From the Boston Recorder.]

A Memoir of Dr. Carey must of necessity give an account of the rise of Baptist Missions in the East Indies, their embarrassments, their struggles, and their success. For this reason, as well as on account of the character of Dr. Carey, it must be a work of intense interest.

[From Zion's Herald.]

The compiler observes in his Preface, that his endeavor has been to exhibit the Christian and the missionary, rather than the scholar. We think he has succeeded. It is in the character of a Christian missionary that Dr. Carey preëminently shines. It was through his labors, under the blessing of God, that a character and stability were given to missionary operations in India, which have justly made them the admiration of the Christian world. We compliment the publishers for the beautiful style in which they have issued this book.

[From the Richmond Religious Herald.]

The name of Carey awakens feelings of the most interesting character in the mind of every reflecting Christian, whose heart is alive to the prosperity of the Redeemer's kingdom on earth, and who longs for the spiritual welfare of a perishing world. The life of the founder of modern missions, the pioneer in those efforts which, we believe, are destined to fill the whole earth with the glory of God, and to cause the kingdoms of the earth to become the kingdoms of the Lord, cannot be perused with ordinary emotions, nor without feelings of devout gratitude, that God was pleased, in his own time, to raise up an instrument so well qualified for the mighty undertaking.

THE COMPLETE WORKS of the Rev. ANDREW FULLER; with a Memoir of his Life. By Andrew Gunton Fuller. *In two volumes.* With a correct Likeness.

This valuable work is now published in two large octavo volumes, on fair type and fine paper, at a very low price. The cost of former editions ($14) precluded many from possessing it. The publishers are gratified in being able to offer to the Christian public a work replete with doctrinal arguments and *practical* religion at a price so reduced that every one desiring such a work may possess it.

[From Rev. Lyman Beecher, D. D.]

Gentlemen:—I cheerfully accord the testimony of my high approbation to the Works of Andrew Fuller. He is one of the few great, original, and holy men, whom God occasionally raises up to dispel the mists which gather about the truth, and bring out the unobscured illumination of the Word of God. No human mind has ever been unerring in all its expositions of revealed truth; but Edwards and Fuller have comprehended, in my opinion, both the letter and spirit of the Bible in an eminent degree. With both I have been deeply conversant, from the commencement of my ministry to the present day, and have uniformly and earnestly recommended to theological students and young ministers, to imbue their minds with their heavenly dispositions, to acquire their habits of accurate definition and discrimination, while they possess themselves of their judicious opinions and powerful arguments. A better service for the truth, to the present day, can scarcely be done, than by the extensive circulation of the Works of Andrew Fuller. May it please the Lord to give you great success in the enterprise.

Yours respectfully, Lyman Beecher.

[A reviewer says,]

This work, in the material and style of execution, is highly creditable to the American press. The publishers, in issuing this work, have conferred an obligation upon the community, and will doubtless be rewarded in a liberal return of their investment. Mr. Fuller was among the few extraordinary men who have ever appeared in this world. He possessed a great vigor of intellect, and an uncommon share of good sense, inflexible integrity, and the most ardent love of truth.

[Another reviewer says,]

The Works of Andrew Fuller have been before the public for several years. Public opinion has passed on them its decisive sentence. They have taken their place among the standard theological writings in the English language.

THE FOUR GOSPELS;

WITH NOTES,

CHIEFLY EXPLANATORY;

INTENDED PRINCIPALLY FOR

Sabbath School Teachers and Bible Classes,

AND AS

AN AID TO FAMILY INSTRUCTION.

BY HENRY J. RIPLEY,

Professor of Biblical Literature and Interpretation in Newton Theological Institution.

[Extracts from the Preface.]

In the following Notes, I have endeavored to avoid prolixity, and yet not to pass over, without explanation, passages that really need explanation. * * * A person who may use this book, either for personal information, or for enabling him to instruct others, must submit to some labor. Frequently passages of Scripture are merely referred to, and the benefit to be drawn from those passages will require that they be examined. Particularly will this be found necessary in the case of a Sabbath School teacher, or the leader of a Bible Class. If such a person depends on this book as a help, he will not find his work all done for him here ; but he will find, I trust, materials afforded him, by which he *may do his work himself.*

Such is the nature of the work I proposed to myself in this book, that I have not felt at liberty, even if I had been disposed or able, to indulge in flights of fancy, or to seek any rhetorical excellence, beyond a perspicuous and simple statement of facts or opinions. Nor have I made many moral reflections. Sometimes I have suggested topics of pious meditation and of useful practical remark ; at other times, I have not done so. I have been guided, in this matter, by the nature of different passages, and by the impressions on my own mind.

That my views of some passages should differ from those of other writers, is to be expected ; but that I have endeavored to convey to my readers the mind of the Holy Spirit, and to shed light over a part of the sacred volume, is my delightful consciousness. The usefulness of the effort must be left to Him, from whom come all good desires and designs, whose blessing is necessary for every undertaking, and " whose approbation can prosper even mine."

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MALCOM'S BIBLE DICTIONARY, Stereotyped and Enlarged. — A Dictionary of the most important Names, Objects, and Terms, found in the Holy Scriptures; intended principally for Sunday School Teachers and Bible Classes. By HOWARD MALCOM, A. M. Illustrated by thirty-nine Engravings on Wood, a Map of Palestine, and an elegant Copperplate Frontispiece.

[From the Minutes of the Vermont State Convention.]

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[From the Minutes of the Boston Association.]

Believing that the advantages of Sabbath School and Bible Class instruction depend greatly on the intelligence of their teachers, and that the extended circulation of Malcom's Bible Dictionary would conduce to their better qualification,—*Resolved,* That this work be recommended to the patronage of the friends of early religious instruction.

LINCOLN'S SABBATH SCHOOL CLASS BOOK. The Sabbath School Class Book, comprising copious Exercises on the Sacred Scriptures. By E. LINCOLN. Revised and improved by an eminent Clergyman and a Superintendent.

The present edition has been thoroughly revised and enlarged by gentlemen well qualified for the task. The book, in its present shape, is one of the cheapest and most complete of the kind now in use. Among the many recommendations of the work, we select the following, which have been received within a few days.

[From Rev. Dr. Going of New York.]

A careful examination of the Sabbath School Class Book convinced me of its high excellence, and observation of its utility *in practice* has *strengthened* the conviction. I therefore fully recommend it as being the best work for Sabbath Schools now in use. JONATHAN GOING.

Gentlemen :—Having examined your Sabbath School Class Book, it gives us pleasure to express our satisfaction with its design and execution. The great benefit which a good class book accomplishes, consists in guiding the mind of the scholar in the study of his lesson, and in suggesting topics of conversation to the teacher. To this end we think your work is well adapted, having avoided, in a great degree, the evils of extreme redundance or conciseness.

W. HAGUE, E. THRESHER,
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